EXHIBIT 10

Expert Opinions of William L. Hall

07/05/2019

Duarte, et al. v. United States Metals Refining Co., et al.

In the U.S. District Court for the District of New Jersey 2:17-cv-01624

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Abbreviations and Acronyms

ACO	Administrative Consent Order
AOC	Area of Concern
BTV	Background Threshold Value
CCA	Copper chromated arsenic
COCs	Constituents of Concern
CSM	Conceptual Site Model
CSW	Chrome Steel Works
EDR	Environmental Data Resources
ESRI	Environmental Systems Research Institute
FRS	Facility Registry System
FS	Feasibility Study
GIS	Geographical Information System
in	Inch
ISDA	Initial Soil Delineation Area
LBP	Lead-based paint
M&T	Metal and Thermit Corporation
NJ	New Jersey
NJDEP	New Jersey Department of Environmental Protection
ppm	Parts per million
RI	Remedial Investigation
SEM-EDS	Scanning electron microscopy with energy dispersive spectrometry
SRS	Soil Remediation Standards
um	Micron
USEPA	United States Environmental Protection Agency
USCS	Unified Soil Classification System
USGS	United States Geological Survey
USMR	United States Metals Refining Company
UTL	Upper Tolerance Limit
XRF	X-ray fluorescence

1.0 Introduction

1.1 Purpose

I have been retained by the Law Office of Vinson & Elkins LLP on behalf of the United States Metals Refining Company in the matter of 2:17-cv-01624, Duarte, et al. v United States Metals Refining Co., et al., in the United States District Court for the district of New Jersey.

This report examines the past operations of the United States Metals Refining Company (USMR) facility in Carteret, New Jersey, associated investigative data, and historical information on the residential and industrial portions of the Borough of Carteret. The objective of the assessment provided herein is identification of the source(s), characteristics, and extent of the metals (arsenic, lead, and copper) in Carteret.

The opinions provided herein represent my conclusions to date based on the materials reviewed and my scientific knowledge. These opinions may be supplemented or modified with additional scientific basis if additional information becomes available.

1.2 Organization

The report is organized as follows:

Section 2.0 - Opinions and Basis

This section provides a summary of my opinions related to the source(s) and extent of metals in Carteret with a brief basis for each individual opinion. Detailed discussion of my analysis for each opinion is provided in Section 5.0 through 9.0.

Section 3.0 - Site and Vicinity Description and History

This section provides an overview of the USMR facility operations and history as well as a summary of remedial activities completed at the Site to date. This section also provides a brief history of the borough of Carteret, other industrial facilities in the area, and an analysis of current housing conditions within the borough.

Section 4.0 – Analytical Approach

This section provides a description of the weight of evidence approach utilized for this report, the types of information reviewed and evaluated, and the information contained in the database utilized for analysis.

Section 5.0 – Opinion 1
Section 6.0 – Opinion 2
Section 7.0 – Opinion 3
Section 8.0 – Opinion 4
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2.0 Opinions Summary

2.1 Overview of Opinions

2.1.1 General

The opinion(s) expressed herein apply to the Carteret community included within the plaintiffs' proposed class area. Beyond the immediate area of the USMR property boundary and the regulatory Area of Concern (AOC), there is no discernable pattern of elevated arsenic, copper, or lead that can be associated with emissions from the former USMR facility. The chemical, physical, and statistical pattern of metals detections in the proposed class area demonstrate that multiple sources produced the metal loading in the community and the metal loading outside the immediate area of the former USMR facility is unrelated to smelter air emissions. The source and extent of metals concentrations varies from property to property and can only be determined based on the characteristics of the individual homes, location in the community (independent of distance from the USMR facility), the physical and chemical characteristic of soils, non-native fill material present, and the history of land use on and near the property.

2.1.2 Description of metals and the urban environment

There are multiple confounding sources of arsenic, copper, and lead in any urban community. These include regional sources such as car and fossil fuel combustion emissions; agricultural uses of insecticides, fungicides, and other pesticides; non-native fill material for foundations, leveling, road construction, or water control purposes; specific point sources from industrial facilities; and household uses, including maintenance and painting, (particularly with lead-based paint and in lead/tin solder), use of treated wood, and historical household use of metals-containing pesticides. All of these sources are or were present in the proposed class area.

Characterizing the source(s) of common metals such as arsenic, copper, and lead in any urban soil system requires consideration of many potential sources and Carteret perfectly illustrates this combination of factors given the age of the community and the multiplicity of land uses over time and potential anthropogenic sources. Specifically, its proximity to New York City and the Arthur Kill led to intensive and varied human activity on the land over its history as well as rapid changes in the relevant land use practices in ways that heavily influence metal loadings. The area was home to extensive farming throughout most of the 19th century and farms continued to be cultivated in the western portion of Carteret into the early 20th century. This farming activity required the use of pesticides, fungicides, and fertilizers. In the later part of the 19th century and early 20th century, a large number of industrial facilities were built along the Arthur Kill to take advantage of shipping access.[1] By 1914, at least 12 metal-related industries were operating in the region. By 1930, the entire southern and eastern portions of the Carteret area along the Kill were lined with industrial operations.

The growth of industry led to a rapid growth in housing in Carteret in the early 1900s. Throughout the industrialization and residential development boom, non-native fill was used throughout the community for land reclamation from low-lying areas, street construction, drainage and foundation structural needs. Fill for these purposes came from a wide variety of sources including coal combustion residuals,

[1] Gravel, 2019. Pg. 7-8/77.

construction debris, and various waste materials or byproducts of local industry. Each of these sources has its own unique potential for metals contamination.

All the above sources contributed to metals loading in Carteret. The interaction of land use activities and sources over time and space are unique for each part of the proposed class area and for each individual parcel and cannot be evaluated on a class-wide basis.

2.1.3 Metals characteristics are inconsistent with USMR Facility emissions (See Discussion in Section 6.0)

Chemical fingerprinting, background analysis, trend analysis, and variography all demonstrate that metals within the Carteret community, outside of the boundaries of the Off-site Area of Concern (AOC), are attributable to sources other than the former USMR facility. Dr. Shahrokh Rouhani has analyzed the metals concentrations using four widely accepted statistical techniques, and in each case the conclusion is the same. The soil data does not display trends or characteristics associated with air deposition of particulates from the former USMR facility, and the metal concentrations must be coming predominately from another source(s). Similarly, microscopy work by Mr. Steve Mattingly demonstrates that the particle size of lead containing particles are inconsistent with those expected from smelter air emissions – providing an additional line of evidence that what is observed in the proposed class area is not a result of the former USMR facility air emissions.

2.1.4 Lead-based paint (see discussion in section 7.1.1)

Lead-based paint (LBP) was popular for many years due to its durability and the surface area a given volume could cover. LBP would have been introduced into the Carteret area in large quantities when the industrialization and housing boom began in the late 19th and early 20th century. LBP is a significant and highly parcel specific source of lead in soils for properties in a community such as Carteret in which the housing stock almost entirely predates 1960.

Analysis based on typical LBP formulations, age of the homes in Carteret, and typical repainting schedules shows that LBP can fully explain the lead concentrations found at the individual properties. Moreover, peer-reviewed studies document soil lead concentrations and yard-area distributions similar to those found in Carteret for similar aged communities where LBP is essentially the only potential lead source. In other words, the lead in the soils of these communities is similar to Carteret, but there is no smelter to point to as a source.

LBP has been unequivocally identified in Carteret soil samples through microscopy, and the significance of LBP impacts are shown by the very strong relationship between housing age (a marker for LBP) and soil lead concentrations as seen in Figure 7-16A (provided at the end of this section). No other trend for metals is as distinct as the relationship between age of homes and lead in adjacent soils.

2.1.5 Localized Applications (see discussion in section 7.1.2)

Metals were utilized in a variety of wood preservatives, insecticides, fungicides, and other pesticides over time. Copper is also a fertilizer, applied as copper sulfate. Copper-chromated arsenic (CCA), a widespread source of metals contamination, was invented in 1933 and has been used in timber treatment since the mid-1930s. In 2003, U.S. manufacturers began a voluntary phase-out of CCA for certain residential uses, but it is still used for treating utility poles, building lumber, wood foundations,

and other industrial uses.[2] Currently, around 70% of homes in the United States have decks or porches containing pressure-treated wood.[3] CCA-treated utility poles are ubiquitous in the proposed class area as seen in Figure 7-17 (also provided below), and CCA-treated wood was positively identified at the named plaintiffs' homes. Since its phase out for residential use in 2003, CCA has been replaced by other preservatives that still contain copper, including ammoniacal copper quaternary and copper azole.[4] Stook et al (2005) found that more copper leaches out of the arsenic-free alternatives than CCA.[5] Inspection of the proposed class area (including samples from the named plaintiffs' homes) documented the common use of copper and arsenic containing treated wood.

Residential use of arsenical herbicides and insecticides are a source of widespread arsenic contamination in residential areas. As an example, in the case of a former lead smelter site near Denver, investigators found widespread metal contamination, as high as 1,000 ppm, attributable to the common use of a lead arsenate-based crabgrass killer common in the 1950s and 1960s.[6] Paris Green (an insecticide containing arsenic and copper) was historically used by households to kill roaches.[7]

The localized correlation of all three metals with residential activities can be observed in Figure 7-14A (also provided below). This figure shows the average concentration in 77 specific residential yards by the decade in which the residence was constructed. The presence of all three metals is correlated with the age of the residences, and likely associated with historical residential use of treated wood, insecticides, herbicides, and fungicides.

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[2] ATSDR, 2007. Pg. 22/559.
[3] National Library of Medicine HSDB Listing for CCA. Pg. 1/35.
[4] Washington Department of Ecology, 2006. Pg. 1/3.
[5] Stook, et. al. 2005. Pg. 1
[6] Folkes, 2001; Folkes, 2010
[7] Gravel, 2019, pg. 29/77.

Figure 7-17. CCA-treated Poles in Carteret.

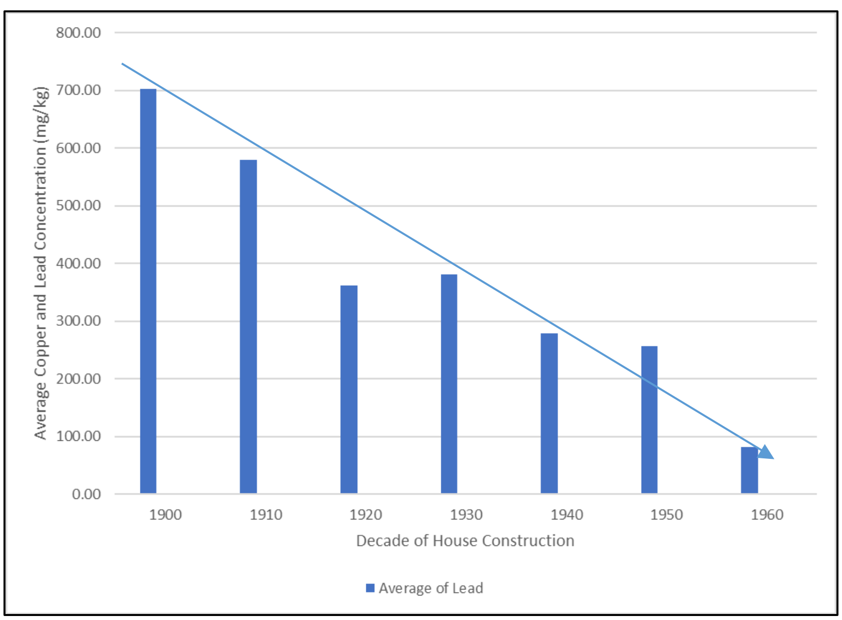

Figure 7-16A. Average Lead by Decade with USMR + plaintiff transect properties included

2.1.6 Industrial sources of fill material (See discussion in Section 7.2)

Carteret was a low-lying area along the shoreline of Arthur Kill that required extensive fill for the industrial and residential development that began in the late 19th century. While the New Jersey Department of Environmental Protection (NJDEP) shows large areas of historic fill along the Kill, non-native fill materials were also widely used throughout Carteret outside of the shoreline areas documented by NJDEP. There are multiple lines of evidence documenting the widespread use of fill on the residential properties located in the proposed class area including:

- Visually identifiable fill layers have been observed at the property excavations within the AOC, frequently with multiple layers observed on the same property. I observed these conditions on my site visit in February 2018. Moreover, my interviews with the remediation teams, the expert report of Lisa Szegedi, and photo documentation from other properties provide additional support.
- The lithology of the soil borings identifies fill in the samples for a large percentage of the borings throughout the entirety of the sampled properties. Even plaintiffs' environmental contractor documented fill in samples.
- Microscopy of the individual samples has confirmed the presence of fill materials originating from a variety of sources.
- Historical City Council meeting minutes and newspaper accounts document the widespread use of fill during Carteret's development.
- Streambeds and adjacent low-lying riparian areas visible on historical maps and aerials are now filled and developed.

The types of fill vary widely from property to property. Nevertheless, NJDEP has published data on the propensity of non-native fill to contain elevated concentrations of metals with potential maximum concentrations of arsenic (1,098 ppm) and lead (10,700 ppm).[8] Each use of fill is unique to the property based on the (i) type of fill used, (ii) the concentration of metals in the fill, (iii) the depth and thickness of the fill, and (iv) the horizontal extent of the fill use.

2.1.7 Parcel Specific Commercial Hotspots (see discussion in Section 7.3)

A review of Sanborn maps in conjunction with the soil data demonstrates that there are 'hot spots' of metals concentrations associated with historical commercial operations identified on the Sanborn maps. These hot spots are highly parcel specific, and, even when not obvious from current land use, can be characterized through examination of available past land use records. Two specific example properties are discussed in detail in Section 7.3. These are properties in which metals concentrations are impacted by unique location specific conditions from past commercial activities.

2.1.8 Commercial Agriculture (see discussion in Section 8.1)

Extensive agricultural activity existed in the Carteret community prior to 1900 and continued in the western portion of Carteret into the 1930s. As discussed in Section 8.1, nearly 1,000 acres of orchard and potato crops were under cultivation in 1870 in the area that is now Carteret based on the 1870 census. This represents approximately 72% of the farmable acres in the proposed class area under active cultivation in 1870. In 1880, this total was approximately 754 acres. Paris green was used for pest control in orchards and potato cultivation by farmers during this period, and the Bordeaux mixture (a

[8] NJDEP, Historic Fill Material and Diffuse Anthropogenic Pollutants Technical Guidance. Pg. 5/47.

copper sulfate mixture) was used to control fungus. As discussed in Section 8.1, there are multiple historical documents supporting the use of these specific chemicals in the Carteret area. Microscopic analysis of the arsenic present in soil samples supports arsenic impacts from a source such as Paris green that can be physically dispersed into very small pores within the soil matrix. This evidence indicates that historical use of these agricultural chemicals contributed metals to the soil.

2.1.9 Leaded Gasoline

Lead can be found along roadways due to historical use of tetraethyl lead in gasoline. Leaded gasoline was introduced in the 1920s and by the 1940s the quantity of lead incorporated in gasoline exceeded that of lead in paint. Leaded gasoline use continued to increase until 1979 and then rapidly declined until it was banned in 1986. Microscopic analysis of soil samples from the proposed class area revealed particles with the morphology and composition consistent with weathered emissions from the combustion of leaded gasoline.[9]

2.2 Specific Opinions

Opinion 1 – Comparison of Soil Characteristics to Plaintiffs' Air Emission Conceptual Site Model

Visual analysis of the horizontal and vertical distribution of the arsenic, copper, and lead concentrations observed in the soil show trends (or lack thereof) that are not consistent with plaintiffs' theory that air deposition of particulates from the former USMR facility is the primary cause of elevated arsenic, copper, and lead concentrations. Similarly, the particle size of the primary lead containing compounds in the soil are inconsistent with Plaintiffs' conceptual site model that is based on deposition of airborne particulates.

Opinion 2 – No Analytical Relationship Exists between Soil Concentrations and USMR

Statistical analysis of the data demonstrates that there is no discernable trend or pattern outside of the immediate vicinity of the former USMR facility that can be attributed to a single source. Specifically, the USMR transect data and Plaintiffs' data display patterns and trends that cannot be attributed to USMR.

Opinion 3 – Parcel-specific Activities Elevated the Metals Load in Carteret

Activities unrelated to the former USMR facility contributed to the mass of arsenic, copper, and lead and created localized elevated concentrations of metals that can only be understood by detailed parcel-specific assessment and cannot be reliably assessed on a class-wide basis. Specifically, evaluation of the vertical and spatial pattern of metals concentrations, historical land use and residential development, historical homeowner activities, low-lying topography and extensive use of non-native fill indicate that metals encountered in the area are a consequence of many anthropogenic activities, including agricultural, industrial, and residential sources.

Opinion 3-1 Metals were Intentionally Used on Parcels by Property Owners

A prevalent direct relationship exists between property-specific characteristics and property owner activities and metals concentrations.

[9] Mattingly, 2019. Pg. 60/64.

Opinion 3-1A Lead-based Paint Parcel Specific Characteristics

For residential properties within the proposed class area, a prevalent direct relationship exists between lead and the age and size of homes. Several lines of evidence demonstrate that LBP is the most likely common factor creating this correlation including: (i) extensive literature describing the relationship between housing age and the extent of painted surface with soil impacts from LBP; (ii) visual observations and data regarding housing age, construction type, and conditions in Carteret; (iii) soil chemical analysis and related spatial patterns; and (iv) microscopic analysis positively identifying the presence of LBP in Carteret soils. The quantity and characteristics of lead on each property is unique to each property in accordance with the specific variables of age and size of home and homeowner home maintenance practices.

Opinion 3-1B- Copper and Arsenic Parcel-specific Characteristics

Outside of the immediate vicinity of the former USMR facility, the distribution of copper and arsenic is highly variable with no correlation to distance from the former USMR facility. The variability is similar to that of lead, indicating that these metals are the consequence of parcel specific activities. These activities included pesticide, herbicide, fungicide, and wood preservative uses both on individual parcels and more generally in the community.

Opinion 3-2- Widespread Use of Fill Material

The use of fill materials was widespread throughout the Carteret area and there are multiple industrial sources of these fill materials. Non-native fill materials like those observed at properties in Carteret are known to be sources of arsenic, copper, and lead.

Opinion 3-3- Historical Commercial Activities

The presence of historical commercial operations within the class area resulted in isolated 'hot spots' of metals concentrations that impacted specific individual properties throughout the proposed class area.

Opinion 4 – Area-wide Activities Elevated the Metals Load in Carteret

The historical record supports that there were widespread agricultural activities within the proposed class area, which would have included pesticides, fungicides, and fertilizers containing arsenic, copper, and/or lead from the mid-19th century through the early 1930s. Agricultural activities created an elevated baseline of metals within the proposed class area and may have also contributed to localized site-specific impacts. In addition to agricultural activities, the widespread use of leaded gasoline through the 1980s resulted in elevated levels of lead in soil throughout the proposed class area.

Opinion 5 – Property-specific Characterization of Metals Sources

Detailed analysis of properties on a property-by-property basis demonstrates that the combination of sources at a given property are unique and definable.

3.0 Site and Vicinity Description and History

3.1 Site Description

3.1.1 Site Overview

The former USMR Site (Site) is located at 400 Middlesex Avenue in Carteret, Middlesex County, New Jersey (Figure 3-1). The Site covers approximately 180 acres across seven parcels. Currently, six of the parcels have been redeveloped and the majority of the Site area is capped with impervious surfaces.[10] Parcel 7 has not yet been redeveloped, but the majority of the parcel has an interim cap with a vegetated soil cover (Figure 3-2).[11]

Figure 3-1. Site Location

Figure 3-2. USMR Site Location

3.1.2 Site Operations

Operations at the Site began in 1902 as the DeLamar Copper Refinery, which operated a copper and precious metals refinery. The DeLamar plant processed blister copper to produce electrolytic wire bars, cakes and ingots, and electrolytically refined gold and silver.[12] In 1906, USMR purchased the DeLamar Copper Refinery, expanded it to increase production, and added different types of products. In 1909, land to the south of the original Site was acquired for slag disposal, and in 1929 the Chrome Steel Works

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[10] ELM, 2016. Pg. 25/428.
[11] ELM, 2016. Pg. 26/428.
[12] ELM, 2016. Pg. 33-34/428.

facility to the north was acquired. In 1967, USMR acquired the Armour Fertilizer plant to use the area for scrap storage, and finally in 1969 USMR acquired the Metal and Thermit Corporation (M&T) property to the north. The M&T property was used as a storage area of used equipment, construction debris, and materials storage.[13]

Initial operations at the Site consisted of a copper and precious metals (gold and silver) refinery. Between 1907 and 1915, the Site expanded to include a copper smelter and additional refinery operations.[14] In the 1940s and 1950s, a secondary scrap aluminum recovery plant was operated on the northern portion of the Site.[15] Between approximately 1960 and 1985, a secondary smelter operated at the Site to reclaim copper from insulated wire and other copper-containing materials.[16] Other operations conducted at the Site include a selenium plant, oxygen-free high conductivity copper manufacturing, a nickel recovery plant, and a laboratory.[17] Shutdown of Site operations began in 1986 and continued until May 1992. All buildings at the Site were demolished by 1995.[18] A timeline of Site operations is provided in Figure 3-3.

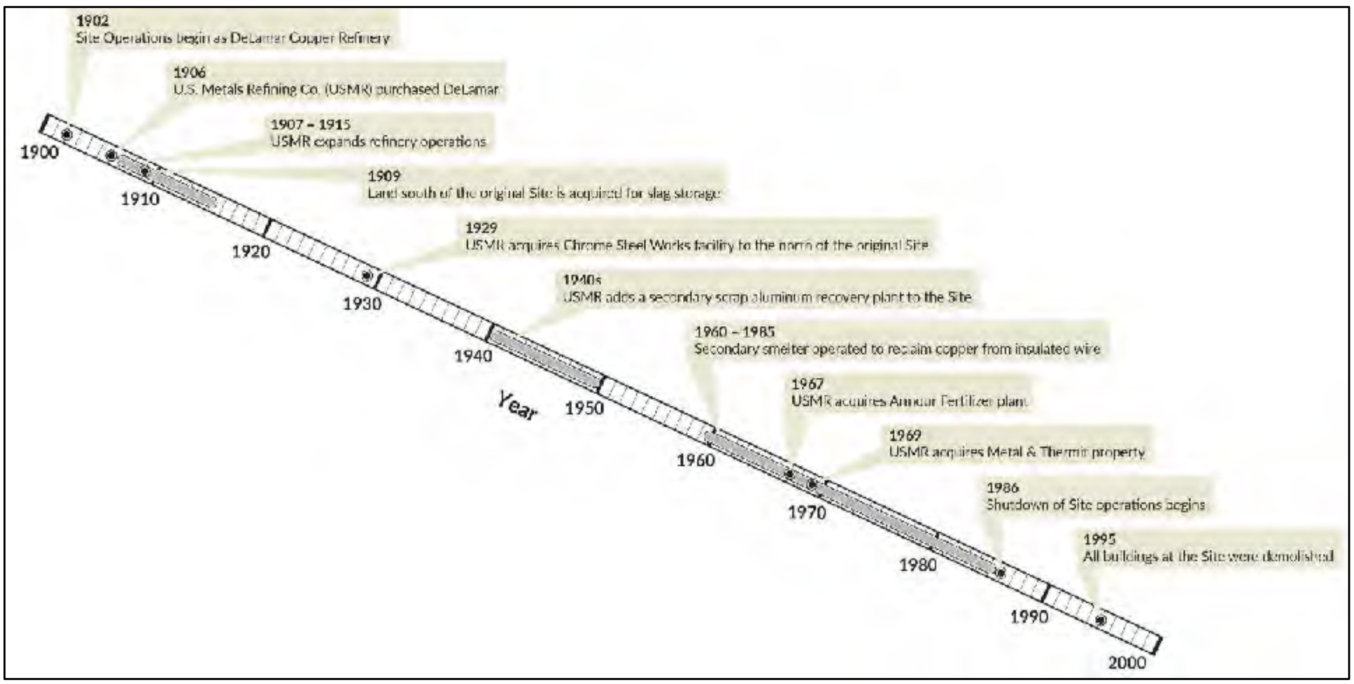

Figure 3-3. Timeline of Site Operations.

3.1.3 Other Historical Facility Operations

Several companies operated at the Site prior to USMR operations. Approximate locations of these historical facilities are shown on Figure 3-4. Chrome Steel Works (CSW) began operations around 1900 and manufactured high strength steel by adding chromium to the furnace charge. Products included

[13] ELM, 2016. Pg. 34/428.
[14] ELM, 2016. Pg. 35/428.
[15] ELM, 2016. Pg. 36/428.
[16] AMAX, 1988. Pg. 56/290
[17] ELM, 2016. Pg. 36/428.
[18] ELM, 2016. Pg. 35/428.

steel plates, angles, bars, and castings. CSW operated until 1929 when the property was acquired by USMR.[19]

The American Lucol Paint Company and Knapp-Mann Whiting plants were located along the Arthur Kill in the northeastern portion of the USMR Site. American Lucol manufactured paint oil, which contained carbon, graphite, iron oxide, red lead and lead zinc paints in various tints, until it was sold to CSW in 1903.[20] Knapp-Mann Whiting was located to the south of American Lucol and processed and dried chalk for whiting agents.[21]

Metal and Thermit Corporation was located on the northern portion of the Site. Operations at the Metal & Thermit facility began in 1910, and Metal and Thermit purchased the property in 1918. Primary operations at the site included recycling tin scrap, tin containers, tin plate, and other tin coated items.[22] In 1962, Metal and Thermit became M&T Chemicals and continued to operate on the property until it was sold to USMR in 1969.[23]

Armour Fertilizer Works operated at the Site from 1909 until 1967, when it was acquired by USMR. [24] Products produced at the site included super phosphates, sulfuric acid, and fertilizer. Sulfuric acid was manufactured using a chamber process where sulfur dioxide, oxygen, and water were combined in the presence of nitrogen oxides to form sulfuric acid. [25] The sulfur dioxide production process produced waste fine materials that contained iron oxides, arsenic, and selenium. [26]

Klipstein Dye Works opened in 1915 to manufacture aniline dyes during World War I. Klipstein closed in 1925 when operations were moved to South Carolina. [27] The Klipstein facility manufactured sulfur dyes, vat blues, and indigo extracts. [28]

[19] ELM, 2016. Pg. 40-41/428.
[20] ELM, 2016. Pg. 41/428.
[21] ELM, 2016. Pg. 41/428.
[22] ELM, 2016. Pg. 42/428.
[23] ELM, 2016. Pg. 42/428.
[24] ELM, 2016. Pg. 42/428.
[25] ELM, 2016. Pg. 42/428.
[26] ELM, 2016. Pg. 42/428.
[27] ELM, 2016. Pg. 42/428.
[28] ELM, 2016. Pg. 43/428.

Figure 3-4. USMR Site Historical Operations

3.1.4 Site Remediation Activities

Remedial investigations and activities at the Site began in 1985 as USMR began to shut down. The majority of on-Site remedial investigations were completed between 1985 and 1989. [29] In 1988, USMR entered into an Administrative Consent Order (ACO) with the NJDEP to conduct a Remedial Investigation (RI) and feasibility study (FS) at the Site and to implement the remedy selected by NJDEP. [30] Extensive soil and groundwater investigations were conducted at the Site during this time frame, culminating in a FS completed in 1991. [31] Remediation activities at the Site began after completion of the 1991 FS and selection of a remedy by NJDEP.

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[29] ELM, 2016. Pg. 43/428.

[30] Arcadis, 2016a. Pg. 11/53.

[31] ELM, 2016. Pg. 54/428.

In 2011, the NJDEP requested a soil investigation be completed to investigate and delineate soil contamination outward from the USMR Site. The Off-Site RI was completed in May 2016 and focused on an 84-acre area referred to as the Initial Soil Delineation Area (ISDA). [32] The ISDA was "located where site-related materials would be expected to be present if air deposition of these metals had occurred". [33] Based on the previous RI's conducted on-Site, arsenic, copper, and lead were selected as constituents of concern (COCs) for the off-site RI. [34]

As outlined in the Off-Site RI, the ISDA was segregated into three zones that would allow for the calculation of a central tendency concentration for each zone, which would then allow for extrapolation of concentration trends to delineate soils that exceed the NJDEP's Soil Remediation Standards (SRS). [35] The ISDA extended from the Site boundary to Roosevelt Avenue. Twenty sample locations were selected for sampling within each zone, with publicly owned properties receiving priority due to easier access requirements. [36] Four samples were collected at each location in six-inch depth intervals down to 24 inches. [37]

The Off-site RI found that the central tendencies of the ISDA data indicated a decline greater than 50 percent in soil concentrations between Zone 1 and Zone 3 for arsenic, copper, lead, and zinc, and that any contribution of metals from historical USMR operations that exceed the NJDEP SRS would be expected to be contained within the ISDA. [38] The boundaries of the ISDA eventually were modified to the slightly smaller boundary of the Off-Site Area of Concern (AOC) for purposes of completing the RI (Figure 3-5). [39]

Subsequent sampling conducted as part of remediation activities within the AOC indicated a need to confirm the boundary of the AOC with additional sampling. [40] To confirm the AOC boundary, samples were collected along three transects extending up to 500 meters beyond the boundary (Figure 3-6). [41] Approximately 20 properties were identified along each transect for sampling, with a minimum of 10 properties to be sampled per transect. With the exception of a few properties along the northwest transect, all selected properties were developed prior to 1950 in an attempt to minimize any potential effects of development/re-development on the sample results. [42] Composite samples were collected from each use area at a given property at depths of 0-6 inches and 6-12 inches and analyzed for arsenic, copper, and lead. [43]

[32] Arcadis, 2016a. Pg. 14/53.
[33] Arcadis, 2016a. Pg. 14/53.
[34] Arcadis, 2016a. Pg. 17/53.
[35] Arcadis, 2016a. Pg. 22/53.
[36] Arcadis, 2016a. Pg. 22/53.
[37] Arcadis, 2016a. Pg. 23/53.
[38] Arcadis, 2016a. Pg. 47/53.
[39] Arcadis, 2016b. Pg. 4/58.
[40] Arcadis, 2016b. Pg. 5/58.
[41] Arcadis, 2016b. Pg. 5/58.
[42] Arcadis, 2016b. Pg. 7/58.
[43] Arcadis, 2016b. Pg. 7/58.

Figure 3-5. Off-site AOC.

Figure 3-6. Off-site AOC and USMR Transects

3.2 Carteret Area Description

3.2.1 Area History

The history of Carteret and the surrounding area can be classified into three primary periods: agricultural, industrial/residential development, and current. All three periods had an impact on the soil conditions that are observed within the plaintiffs' proposed class area today.

Agricultural Period

Prior to 1900, Carteret and much of Middlesex County was rural in nature and agriculture was one of the largest economic activities in the county.[44] The area was sparsely populated, and the majority of people that did live in the area were farmers. An 1850 map of the portion of Woodbridge Township that later became Carteret identifies several landowners spread across the Carteret area, with unpopulated areas consisting of forested land or marshland (Figure 3-7). The 1850 Census identified at least seven farmers in the Carteret area, all of whom grew Irish potatoes and all but one had orchard produce.[45] The 1870 census identified 11 farmers in the Carteret area, all of whom grew Irish potatoes and six of whom also had fruit orchards.[46] Similar farming patters were also identified in the 1880 census.[47] While farming in

[44] De Angelo, n.d. Pg. 53/84.
[45] Gravel, 2018. Pg. 5/74.
[46] Gravel, 2019. Pg. 13-14/77.
[47] Gravel, 2019. Pg. 14-15/77.

the eastern portion of the proposed class area had largely ceased by the early 1900s, an analysis of aerial photography from 1931, 1940, and 1947 indicates that farming continued in the western and northwestern portions of the proposed class area into the early 1930s.[48] The farm activity included the production of potatoes, and potato farmers were frequent users of arsenic/copper-based insecticides and copper-based fungicides.

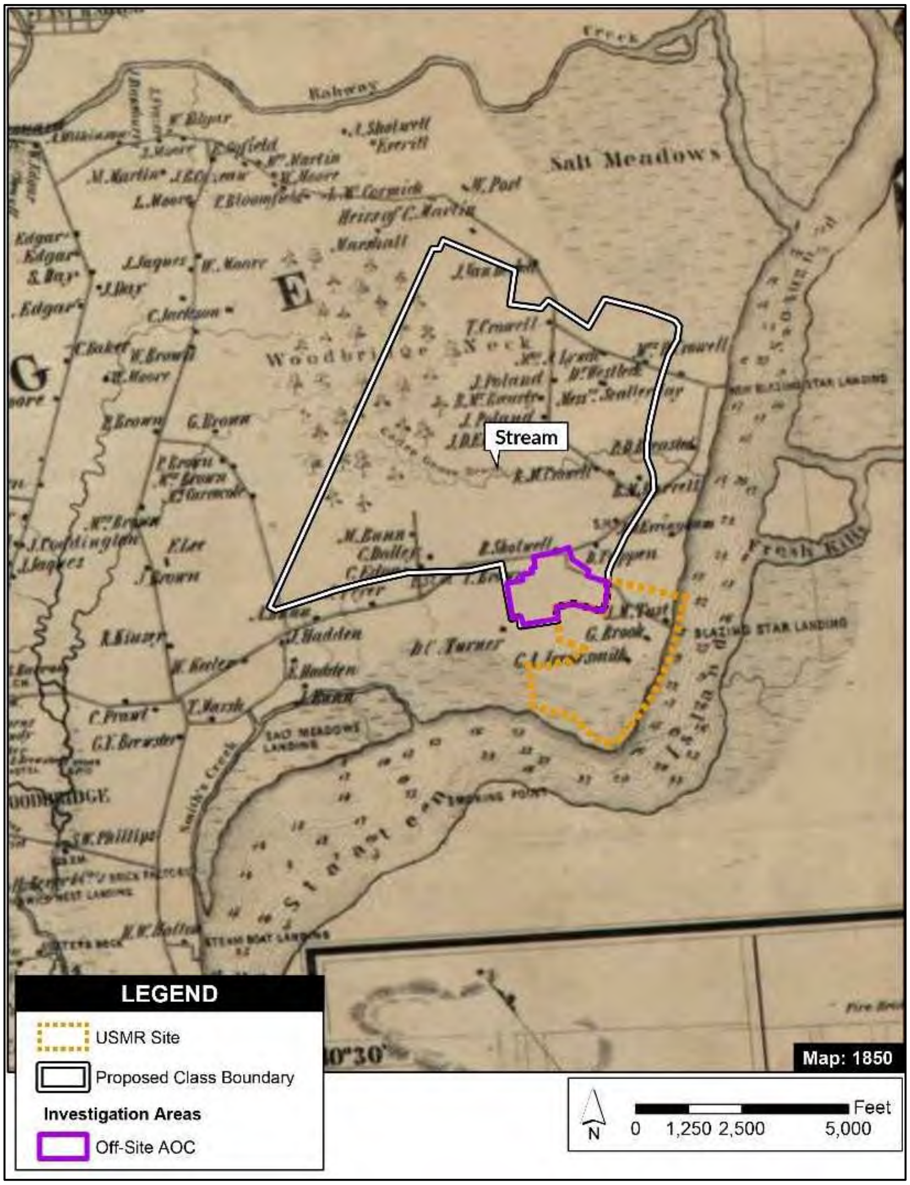

Figure 3-7. 1850 Map of Carteret

Industrial and Residential Development

By 1900, Middlesex County could no longer be called strictly an agricultural community.[49] Between 1900 and the 1950s, the Carteret area experienced rapid growth and expansion, as the economy of the region

[48] Stout, 2019. Pg. 2-3/11

[49] De Angelo, n.d. Pg. 56/84

shifted away from agriculture to manufacturing and other industrial operations. The Borough of Carteret was originally incorporated as the Borough of Roosevelt in April 1906 from a portion of Woodbridge Township. The name of the borough was changed to Carteret in November 1922.[50]

Carteret's location along the Arthur Kill was ideal for industry. By the late 1800s and early 1900s a large number of industries were located along the Arthur Kill to take advantage of shipping access.[51] By 1914, at least 12 metal-related industries were operating in the region. By 1930, the entire southern and eastern portions of the Carteret area along the Kill were lined with industrial operations (Figure 3-8).

With the growth in industry also came a growth in housing as more people moved to the area. Housing, which had been concentrated around the industrial operations in eastern Carteret began to slowly expand westward. Section 3.2.2 provides a more detailed discussion of housing development.

Figure 3-8. 1930 Aerial of Carteret

[50] Gravel, 2019. Pg. 7/77.
[51] Gravel, 2019. Pg. 7-8/77.

Current Day

Since the 1950s, Carteret has continued to grow. The southern and eastern portion of Carteret along Arthur Kill continues to be primarily commercial/industrial, although recently operations in the area have transitioned away from active manufacturing toward warehousing and shipping. Carteret experienced a large housing boom in the 1950s, with the western half of the Borough being developed in the 1950s and 1960s.

3.2.2 Area Housing Development

With the growth in industry starting around 1900 came a rapid growth in housing in Carteret. Large-scale housing development originally focused on the southern and eastern portions of Carteret, along the current day Roosevelt Avenue. These areas were closest to the industrial facilities along Arthur Kill, and some of the earliest residential construction in Carteret was company-owned housing for employees. Between 1910 and 1930, as the Carteret area continued to grow, housing began to expand to the north and west, further inland from the Kill (Figure 3-9).

Housing gradually increased and continued to move further inland from the Kill between the 1930s and 1950. In the early 1950s, particularly starting in 1953, housing growth exploded in Carteret. In 1953 the rate of housing construction almost tripled from the previous year. By the end of the decade, over 2,300 new properties had been developed in the 1950s, more than doubling the existing amount of developed properties. The housing growth in the 1950s was primarily along Carteret Avenue, extending out to the New Jersey Turnpike. Based on a review of historical imagery from 1930, many of these homes were built on former agricultural land (Figure 3-10).

There was another housing expansion, albeit smaller than the 1950s, in the late 1960s, primarily in areas that had yet to be developed along the NJ Turnpike. Since the 1960s, the housing footprint has remained largely unchanged with a number of the 1900s-era properties near Roosevelt Avenue being demolished and re-built (Figure 3-11).

Figure 3-9. Early Housing with 1930 Aerial

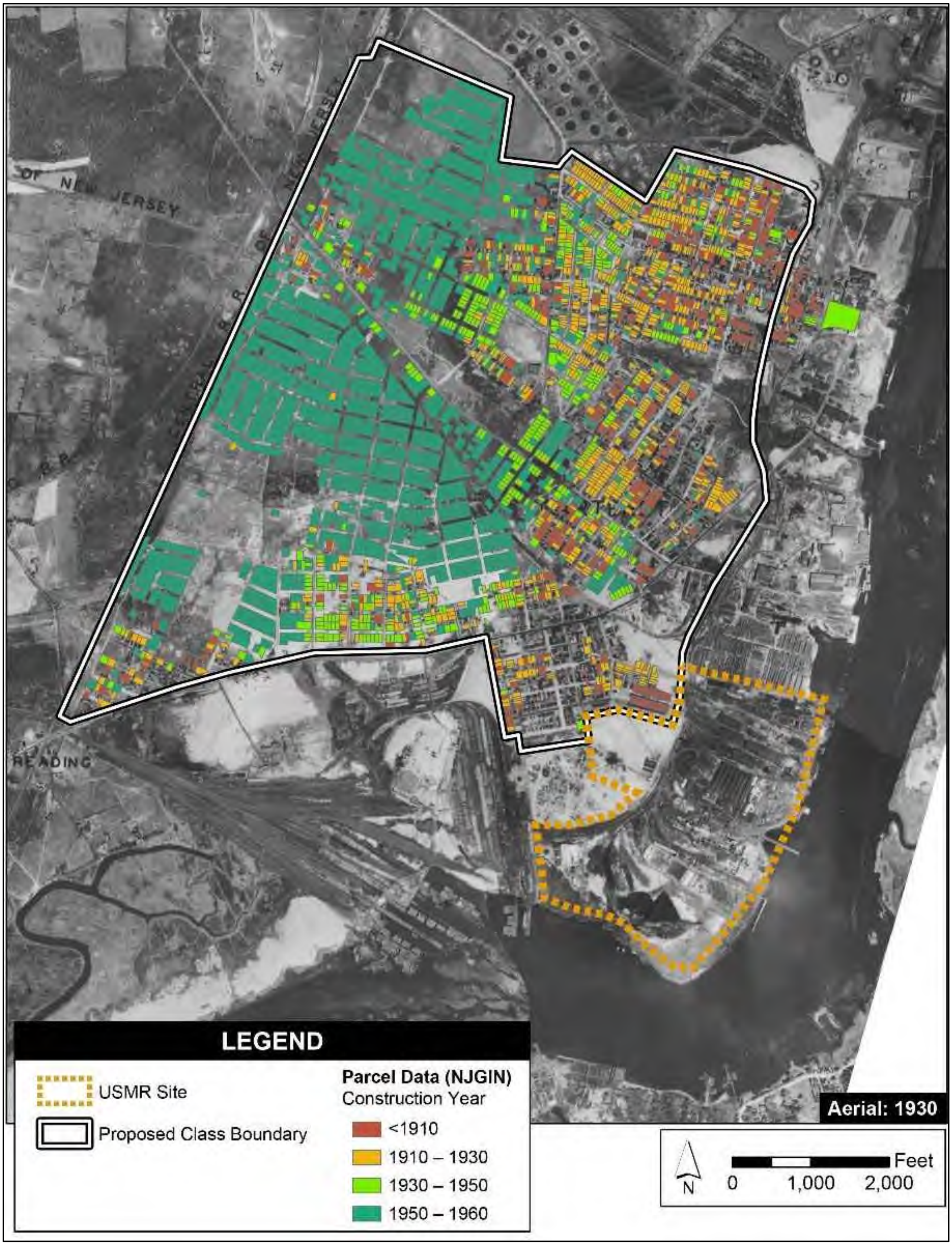

Figure 3-10. Housing through the 1950s

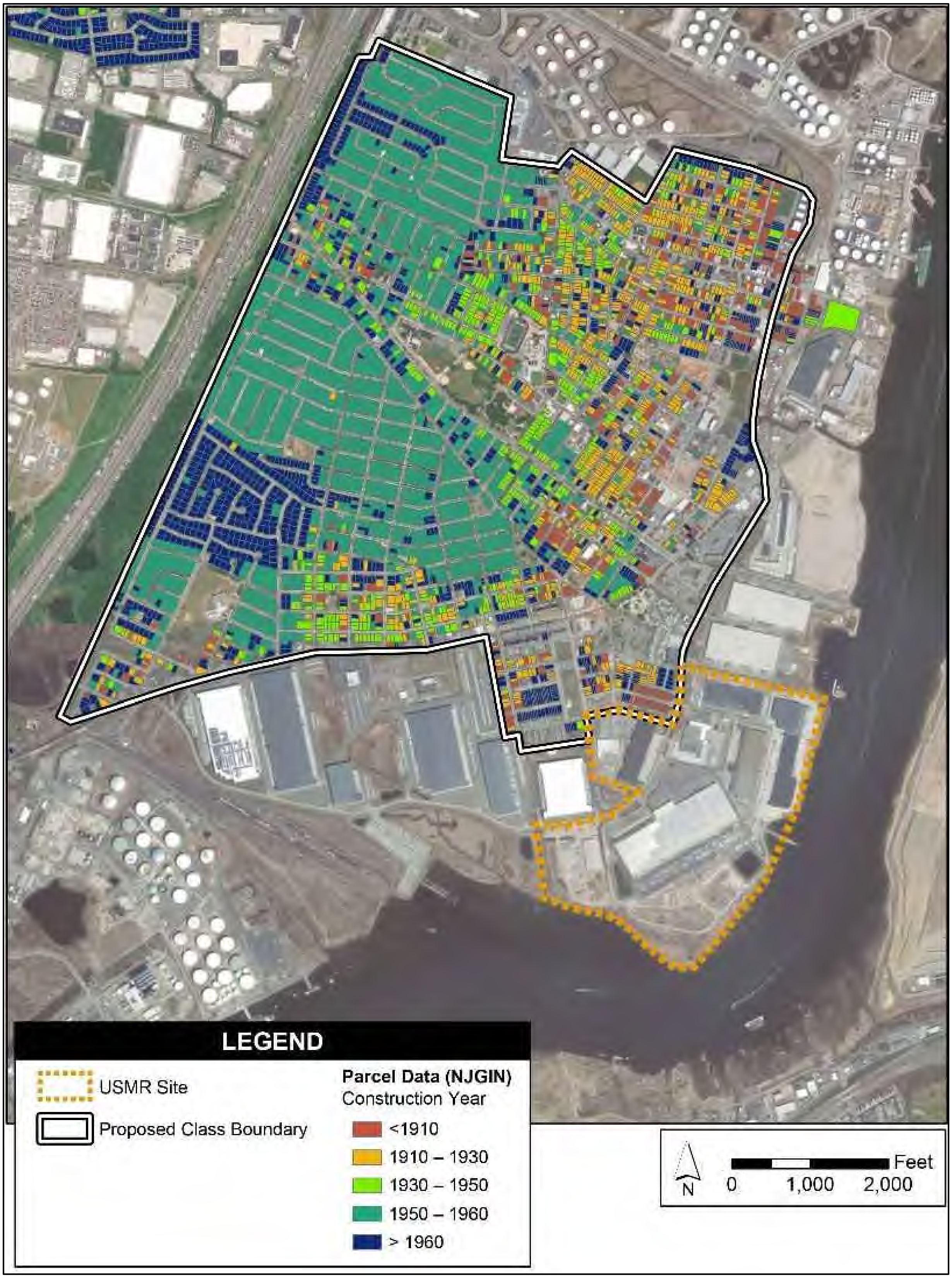

Figure 3-11. Current Aerial with Age of Construction

Housing Types

Housing types vary across the Carteret area and generally vary based on age. The earliest housing in Carteret (pre-1900) is generally multi-family, row-house style housing that was built for employees of the industries located along the Kill. Many of these buildings are painted brick or painted stucco (Figure 3-12). In the early 1900s, housing transitioned to more single-family houses. These houses are typically two to three stories tall and currently have siding as the primary exterior type; there are relatively few single-family brick houses located in Carteret. Early housing in Carteret is generally on very small lots consisting of a small front yard, a narrow alley between houses, and a small backyard. Based on available tax data, properties constructed prior to 1930 have an average parcel size of 0.1 acres (4,350 square feet).

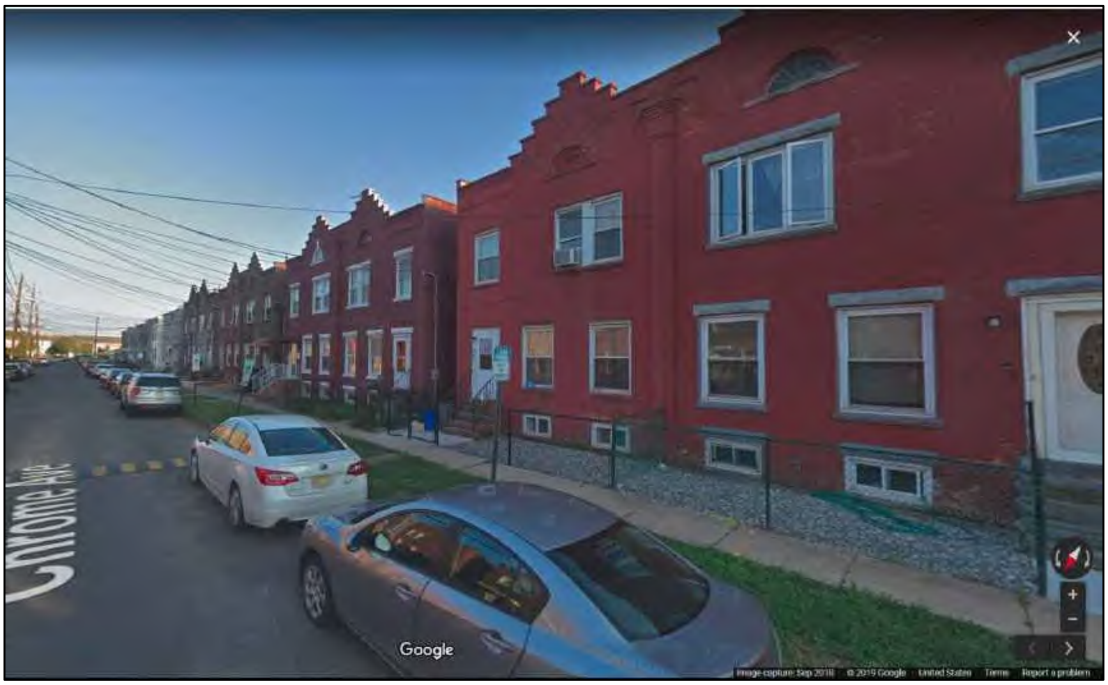

Figure 3-12. Early housing along Chrome Ave (Source: Google StreetView)

As housing development expanded to the west towards the NJ Turnpike, housing transitioned to almost exclusively detached single-family housing with larger lot sizes. Properties developed beginning in the 1950s are typically 1 to 1.5 story ranch or split-level style houses with siding as the primary exterior type. These properties are also located on slightly larger lots, with an average parcel size of 0.14 acres (6,100 square feet) (Figure 3-13). Housing conditions are discussed in more detail in the following section.

Figure 3-13. Example of 1950s housing (Photo from February 2018)

3.2.3 Area Housing Conditions

In August 2018, NewFields personnel conducted a property inspection throughout the proposed class area. As part of the inspection process, desktop and sidewalk inspections were conducted on 550 parcels throughout the class area. The proposed class area was divided into 12 housing blocks based on the general year of construction for the housing stock within the block (Figure 3-14). Between 39 and 59 properties were randomly selected within each block utilizing a stratified random sampling procedure[52]. Any vacant or commercial properties that may have been selected were replaced by randomly selected residential parcels. Inspected properties are shown on Figure 3-15.

[52] Properties to be inspected were randomly selected within each housing age block. The number of properties inspected in each block represents the number of parcels that need to be investigated within each block in order to reach the specified confidence level that at least one of the investigated parcels is within the top 5% significant parcels in a given block. Confidence levels range from 85% to 95% based on the average year of construction.

Figure 3-14. Housing Year of Construction

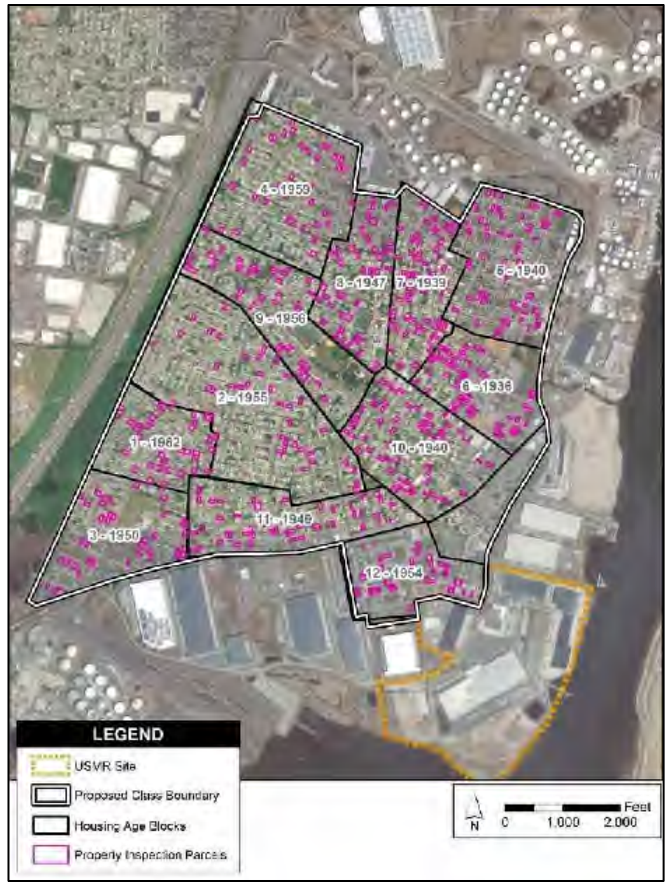

Figure 3-15. Property Inspection Parcels

During the desktop review process, publicly available real estate data was reviewed using real estate websites such as Zillow and Redfin. Current and historical aerial imagery was also reviewed, and observations were noted in a spreadsheet. Following the desktop review, NewFields personnel completed a sidewalk inspection of all selected properties between August 13-17, 2018. During the property inspection process, the following information was captured on each property:

- Age of construction
- Square footage
- Number of stories
- Primary exterior material and corresponding percentage
- Secondary exterior material and corresponding percentage
- Percent of the exterior that is painted
- General condition of structure
- Visible peeling paint
- Indications of treated wood
- Other structures present on the property (shed, garage, etc.)
- Condition of paint on other structures, if painted
- Other miscellaneous comments or observations

The year of construction of inspected properties ranged from 1883 to 2016 with an average of 1945 (Table 3-1). Ninety-two percent of properties were constructed prior to 1978, when lead-based paint was banned for residential use.

Table 3-1. Summary of Construction Dates for Inspected Properties.

Decade of Construction	Number of Properties	%
1880	2	0%
1890	4	1%
1900	44	8%
1910	66	12%
1920	73	13%
1930	13	2%
1940	47	9%
1950	149	27%
1960	76	14%
1970	29	5%
1980	13	2%
1990	3	1%
2000	19	3%
2010	11	2%
Pre-1978	**506**	**92%**
Post-1978	**44**	**8%**

The primary exterior type was vinyl or wood siding (Table 3-2). Nearly 80 percent of inspected properties had either vinyl or wood siding as the primary exterior type. Approximately 15 percent of inspected properties were brick. Vinyl siding was not introduced into the marketplace until the late 1950s. [53] For homes predating the late 1950s, vinyl siding must be installed over an original material, most likely brick or wood siding. Even for homes constructed after the late 1950s, the vinyl siding is likely placed over an original non-vinyl siding material as this building material was not dependably durable until the 1980s, and broad market acceptance did not occur until that time.[54] Ninety to 95 percent of the housing in Carteret was constructed by this time.[55] Evidence of the subsequent placement of vinyl siding over original painted surfaces was observed in the community. For example, during the property inspections, a painted surface was observed beneath siding on a house built in 1947 that was being renovated (Figure 3-16).

[53] Vinyl Siding Institute, 2012..

[54] Ibid.

[55] Based on County tax records, approximately 5,200 out of approximately 5,700 were constructed by the mid-1980s.

Table 3-2. Summary of Primary Exterior Types of Inspected Properties

Primary Exterior Type	Count	%
Wood Siding	230	42%
Vinyl Siding	207	38%
Brick	84	15%
Composite Siding	10	2%
Stucco	8	1%
Wood Shingles	5	1%
Brick Veneer	1	0%
Stone	1	0%
Stone Veneer	1	0%
Wood Siding/Wood Shingle	1	0%
Wood/Vinyl Siding	1	0%
Brick Veneer and Wood	1	0%

Figure 3-16. Renovated house showing painted surface underneath siding

Other structures, primarily garages and sheds, are common throughout Carteret. Nearly 30 percent (157) of the properties had a detached garage, and 34 percent (185) of the properties had a shed. These other structures are typically found at older properties, with the majority of garages and sheds being found at properties constructed between 1900 and 1959 and almost all of the structures were at properties constructed prior to 1978 (Table 3-3). These structures are typically painted and often exhibit peeling paint. While these structures were often difficult to view from the street or sidewalk, peeling paint, which was visible from the sidewalk, was observed on garages and/or sheds at 56 of the inspected properties. In general, the condition of these other structures was worse than the condition of the house on the same property.

Table 3-3. Properties with Detached Garages and Sheds by Decade

Decade	Count of Detached Garages	Count of Sheds
1880	1	1
1890	1	2
1900	13	11
1910	32	15
1920	42	19
1930	10	2
1940	22	12
1950	31	59
1960	1	41
1970	2	13
1980	0	4
1990	0	2
2000	0	3
2010	1	0
Pre 1978	156	175
1978 or later	1	10
Total	**157**	**185**

Approximately 90 percent (474 properties) of the inspected properties had exteriors that were at least 50 percent painted. Of those, 152 properties, or 32 percent, had visible signs of peeling paint. All but four of the properties with visible peeling paint were constructed prior to 1978 when lead-based paint ceased to be sold for use in residential applications. Properties with visible peeling paint are summarized in Table 3-4.

Table 3-4. Number of Properties with Visible Peeling Paint

Decade	Count of Peeling Paint
1880	0
1890	1
1900	17
1910	25
1920	25
1930	5
1940	14
1950	37
1960	17
1970	6
1980	1
1990	0
2000	3
2010	0
Pre 1978	148
1978 or later	4

4.0. Analytical Approach

4.1 Database

NewFields compiled an environmental database for the Carteret area. The database includes soil data collected by USMR from the former USMR site, the AOC, and the transects outside of the AOC as well as soil data collected by the plaintiffs (Table 4-1). Soil data from the AOC was collected under the residential clean-up program and provided to NewFields by GHD. Lithology information for all AOC and transect soil samples was downloaded from USMR's TIA database system. In the plaintiff dataset, there are several instances where the provided sample location coordinates do not match up with the listed street address. For these properties, I am relying on the provided sample coordinates and not the listed street address.

Several of the analyses included in this report focus on 77 properties (transect properties) along three transects emanating from the former USMR facility outside of the regulatory AOC (Figure 4-1). Thirty-eight of the properties were sampled by representatives of USMR (USMR samples) and 39 by representatives of the plaintiffs (plaintiff samples). For the USMR and plaintiff samples, discrete samples were collected for the 0-6 inch and 6-12 inch soil layers. There were 10 locations sampled for each USMR-sampled property, distributed randomly around the non-paved portion of the properties. The location of the samples for each of the USMR-sampled properties is shown in Appendix A Figures A-1 through A-12. There were two to three sample locations for each property sampled by the plaintiffs as shown in the Appendix A figures. Each USMR-sampled property has a total of 20 samples (plus two field duplicates) and each plaintiff sampled property has a total of 6 to 8 samples.

Table 4-1. Summary of Database Records

Investigation Area	Number of Locations	Number of Samples	Number of Results
Former USMR Site	336	734	2,073
AOC	4,349	24,908	74,724
Transects	380	835	2,505
Plaintiff Data	127	254	762

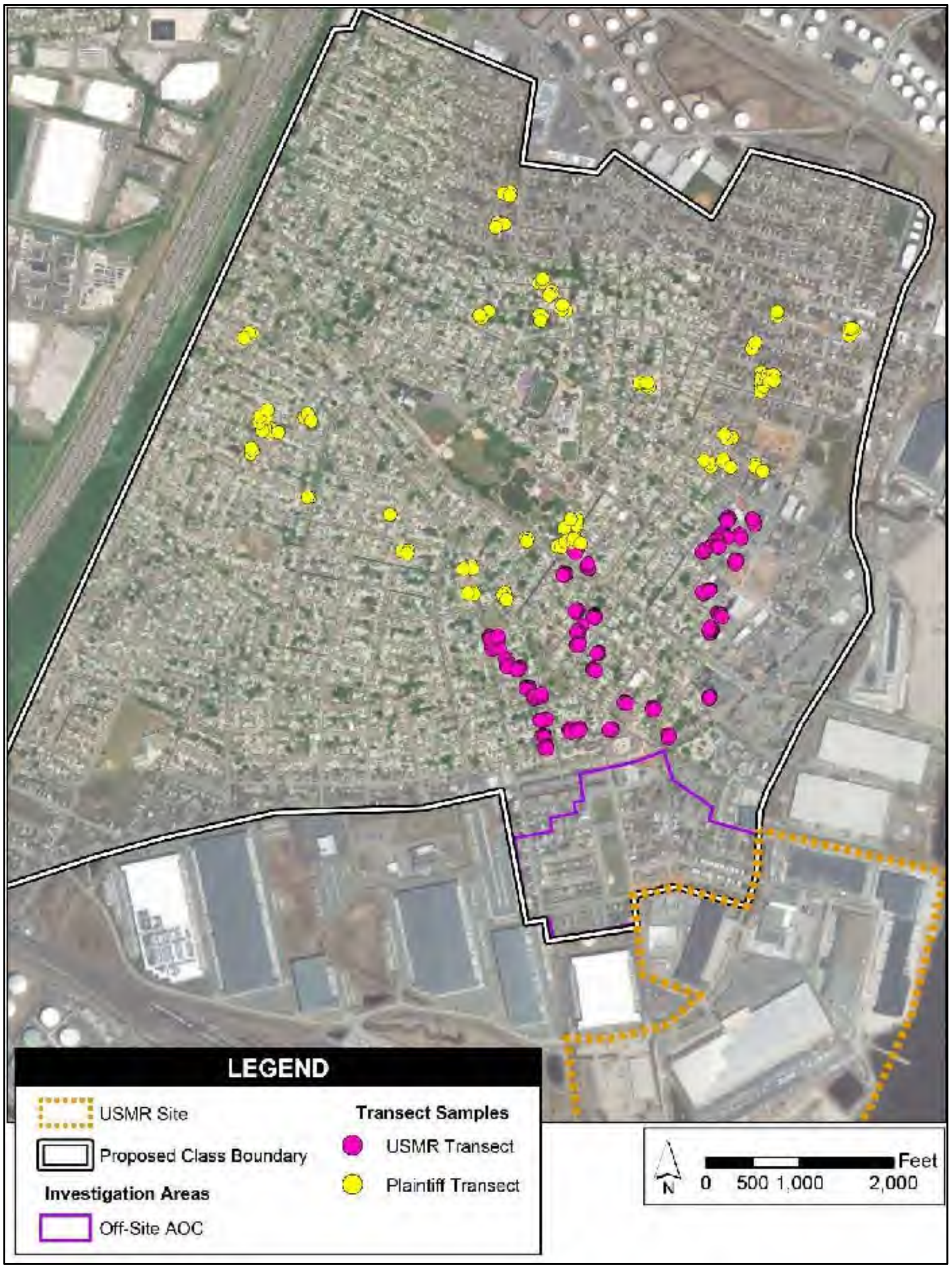

Figure 4-1. USMR and Plaintiff Transect Parcels

4.2 Geographical Information System

The NewFields database is linked to a Geographical Information System (GIS) where verifiable geographic locations are available. A GIS and its application components are tools for evaluating spatial and temporal patterns of environmental data with respect to other geographic data, such as:

- Topography
- Geologic Data
- Tax Assessor Parcel Data
- Housing Age

- Roads/Streets/Rail features
- Aerial photography
- Sanborn Insurance Maps

GIS data sources used for the GIS include:

- United States Geological Survey (USGS)
- New Jersey Geographic Information Network
- Environmental Data Resources (EDR)
- United State Environmental Protection Agency (USEPA)
- Environmental Systems Research Institute (ESRI)

The above described database and GIS were used to support and develop the opinions provided in this report.

4.3 Analytical Approach

The opinions and conclusions in this report are based on a multiple line and weight of evidence approach. There is an extensive database containing a high level of spatial and vertical granulation on soil metals, supporting data and information on metals in the environment and building materials, extensive data on historical activities, and in-depth information on the various anthropogenic sources of contaminants in the area. The variety of data types and detail allows the application of a variety of analytical tools. These include empirical examination (observation) of spatial patterns, visual analytics, statistical analysis, microscopic analysis, and correlation between various data types and analysis. The data can be examined and analyzed from many perspectives to obtain a multi-dimensional view of the environmental conditions, as well as test the validity of conclusions from any one line of investigation. The various types of analysis or lines of evidence provide a means to test and weigh the strength of any conclusion regarding source, fate, and impact of contaminants.

The weight of evidence that is the product of this analysis allows for the development of a well substantiated conceptual model that is consistent with the available data and information and is not rendered unlikely or contradicted by any relevant data or information. The following data and information types were reviewed and evaluated independently:

- Soil samples including concentration and geospatial assessments
- Analysis of housing construction characteristics relevant to property lead loading from the historical use of lead-based paint and arsenic loading from treated wood
- Property-specific mass balance analysis to evaluate the potential range of lead loads brought onto parcels with LBP
- Property inspections conducted by NewFields personnel
- Sanborn maps and historical data on industrial and commercial operations in Carteret
- Soil geostatistical analysis (Rouhani Report) including trend analysis, variography, chemical fingerprints, and background analysis
- Historical review (Gravel Report) of agricultural practices in the Carteret area and associated use of copper-containing agricultural chemicals and use of non-native fill in the historical development of Carteret
- Microscopic analysis (Mattingly Report) of soil samples from the Carteret area analyzing various sources of metals and photo documentation of observations during property excavations

5.0. Opinion 1 - Comparison of Soil Characteristics to Plaintiffs' Air Emission Conceptual Site Model

Visual analysis of the horizontal and vertical distribution of the arsenic, copper, and lead concentrations observed in the soil show trends (or lack thereof) that are not consistent with plaintiffs' theory that air deposition of particulates from the former USMR facility is the primary cause of elevated arsenic, copper, and lead concentrations. Similarly, the particle size of the primary lead containing compounds in the soil are inconsistent with Plaintiffs' conceptual site model that is based on deposition of airborne particulates.

5.1 Visual Concentration Patterns

The first step in the visual evaluation of spatial trends in the soils for the COCs (arsenic, copper, and lead) was a post plot of all point data based on concentration ranges. Concentration ranges were developed by utilizing the NJDEP SRS numbers. The post plot allows for visual assessment of concentration gradients across the sampled portion of the proposed class area. Figures 5-1 – 5-3 are the post plots for arsenic, copper, and lead. These figures show a high degree of spatial variation in metals concentrations with no visually obvious trend or pattern to the data except in the immediate vicinity of the Site property boundary.

In addition to the post plots, concentration depth profiles were created for each COC. Specifically, concentration versus sample depth was plotted to assess vertical trends (Figures 5-1 – 5-3). Figure 5-1 shows that arsenic concentrations are highest at the 6-12 inch and 12-18 inch intervals and lower on average at the surface. There is then a gradual decline in concentration observed in samples below 18 inches, but with relatively elevated concentrations encountered at four feet below ground surface. Lead shows a similar pattern to arsenic, with the highest concentrations observed between 6-18 inches below ground surface, a gradual decline, and then relatively elevated concentrations at four feet below ground surface (Figure 5-3). Copper concentrations show more of a decline with depth but again are at their maximum between 6-18 inches below ground surface with lower concentrations at the surface and a zone of elevated concentrations at four feet below ground surface (Figure 5-2). These depth profiles do not show the typical concentration profile associated with aerial deposition where metal concentrations are at their maximum at the surface where the initial particulate deposition occurs and then decrease exponentially with depth. Additionally, the changes in relative concentrations between layers among the three metals indicates that these concentrations are not from a single source.

Due to the density of individual sample points, it is difficult to discern horizontal spatial trends in the post plots. This high variability, or "noise", in metals concentrations over short distances makes it difficult to visualize larger scale trends. To address this, average concentrations per sampled parcel were calculated and mapped according to parcel boundaries rather than sample points. The average concentration was calculated for the 0-24 inch interval to represent the most conservative scenario. The calculated averages were assigned to each corresponding parcel and mapped to illustrate the general horizontal spatial trends for each COC. The mapping shows that there are unique and differing spatial distributions for each COC (Figures 5-4 – 5-6). While exceedances of arsenic and lead NJ SRS criteria are relatively common within the AOC, there is no common visual pattern across the three COCs. Outside of the AOC, exceedances of the NJ SRS criteria are limited to lead and arsenic and are spatially random and isolated.

5.2 Particle Size Analysis

Particle size is a key characteristic in determining if a given particulate could be atmospherically distributed. In his report, Plaintiffs' expert Dr. Flowers states that the expected particle size distribution from smelter air emissions should be less than 53 microns with most falling between 5 and 50 microns.[56] In his analysis, Mr. Mattingly found:

> "Forensic microscopy… demonstrated that Pb was widely observed in particles greater than 100 um [microns] in the form of paint chips and slag. Arsenic was detected in the AOC as natural minerals or deposits on Fe [iron] containing particles greater than 100 um."[57]

These materials were greater than 100 microns in size, and thus cannot be the result of aerial deposition from the former USMR facility.[58] Mr. Mattingly concluded that based on his microscopy "there is no evidence that particulates originating from the former USMR facility air emissions are present in the transect samples collected outside the AOC, and the analytical techniques used as part of this study are capable of identifying these particulates if they are present."[59]

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[56] Flowers, 2019b. Pg. 11/63.
[57] Mattingly, 2019. Pg. 59/64.
[58] Mattingly, 2019. Pg. 59/64.
[59] Mattingly, 2019. Pg. 58/64.

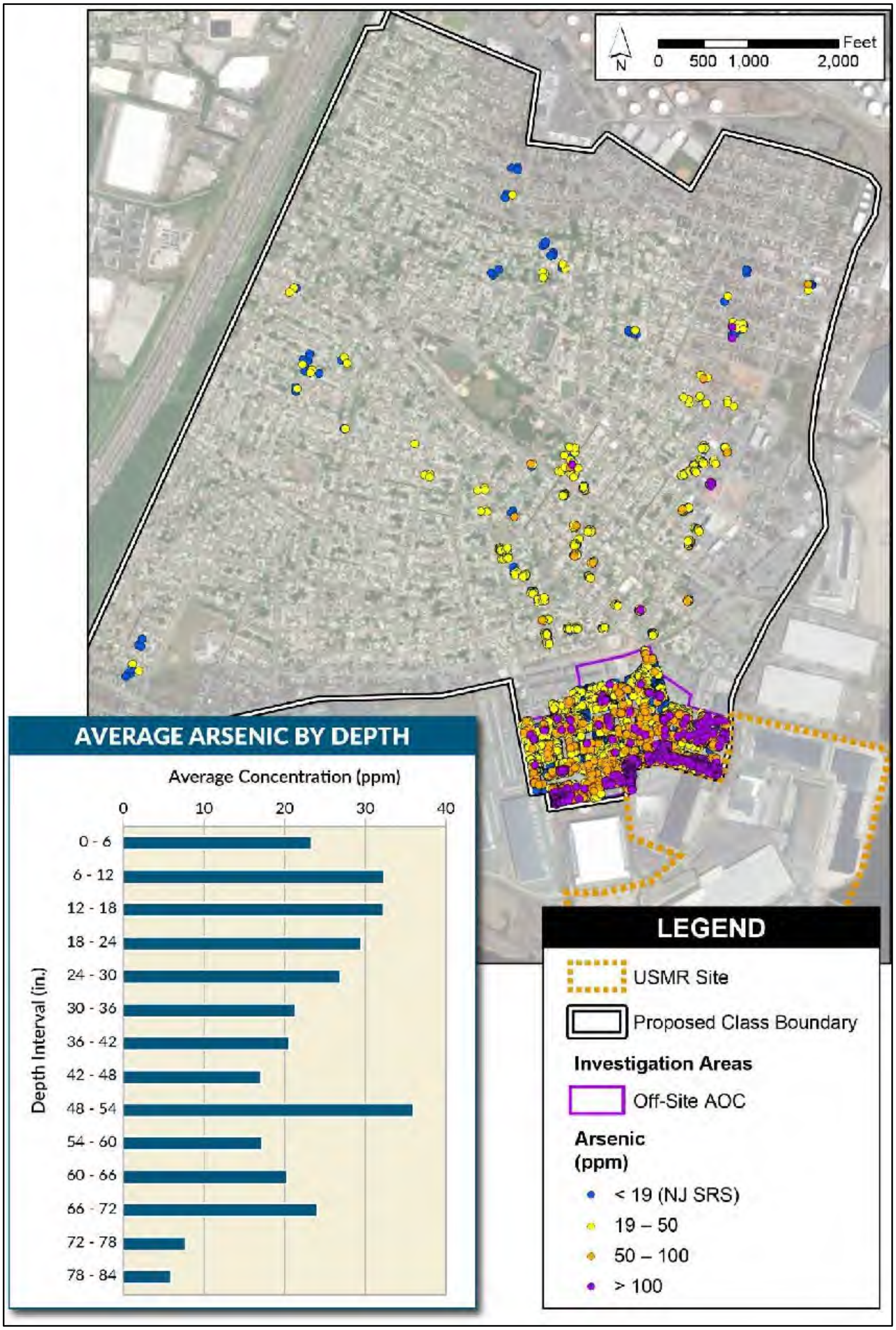

Figure 5-1. Arsenic in Soils

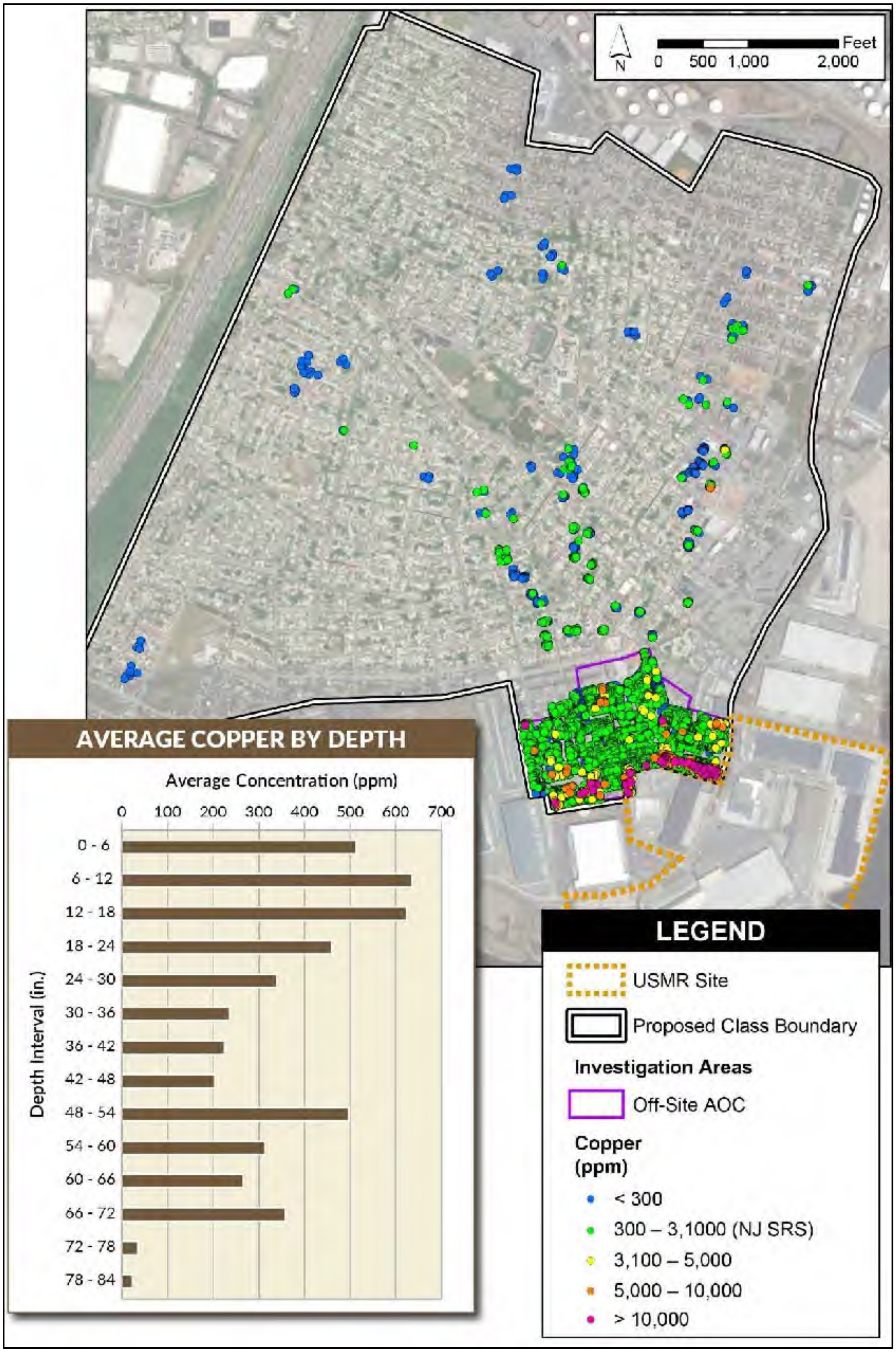

Figure 5-2. Copper in Soils

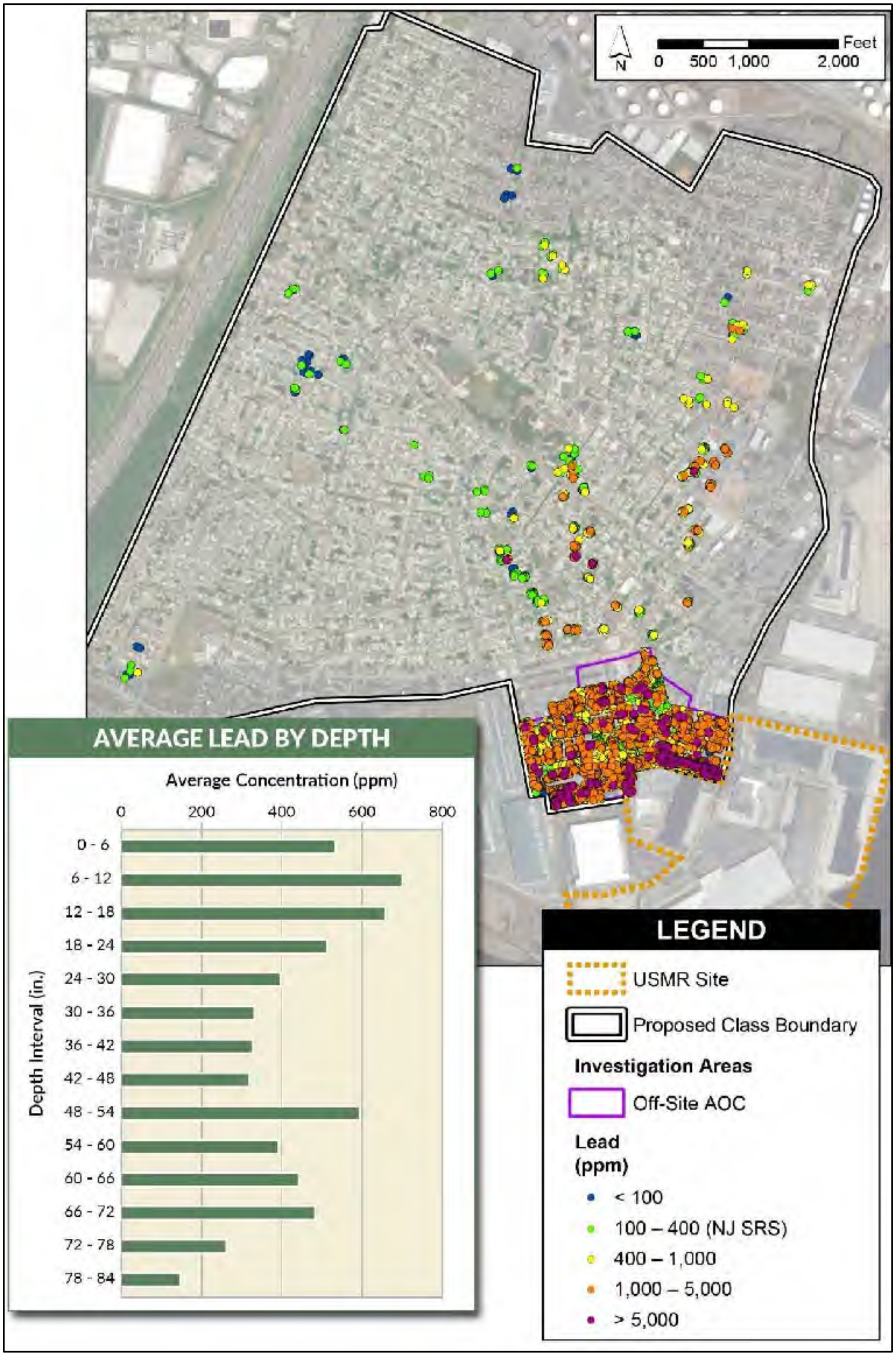

Figure 5-3. Lead in Soils

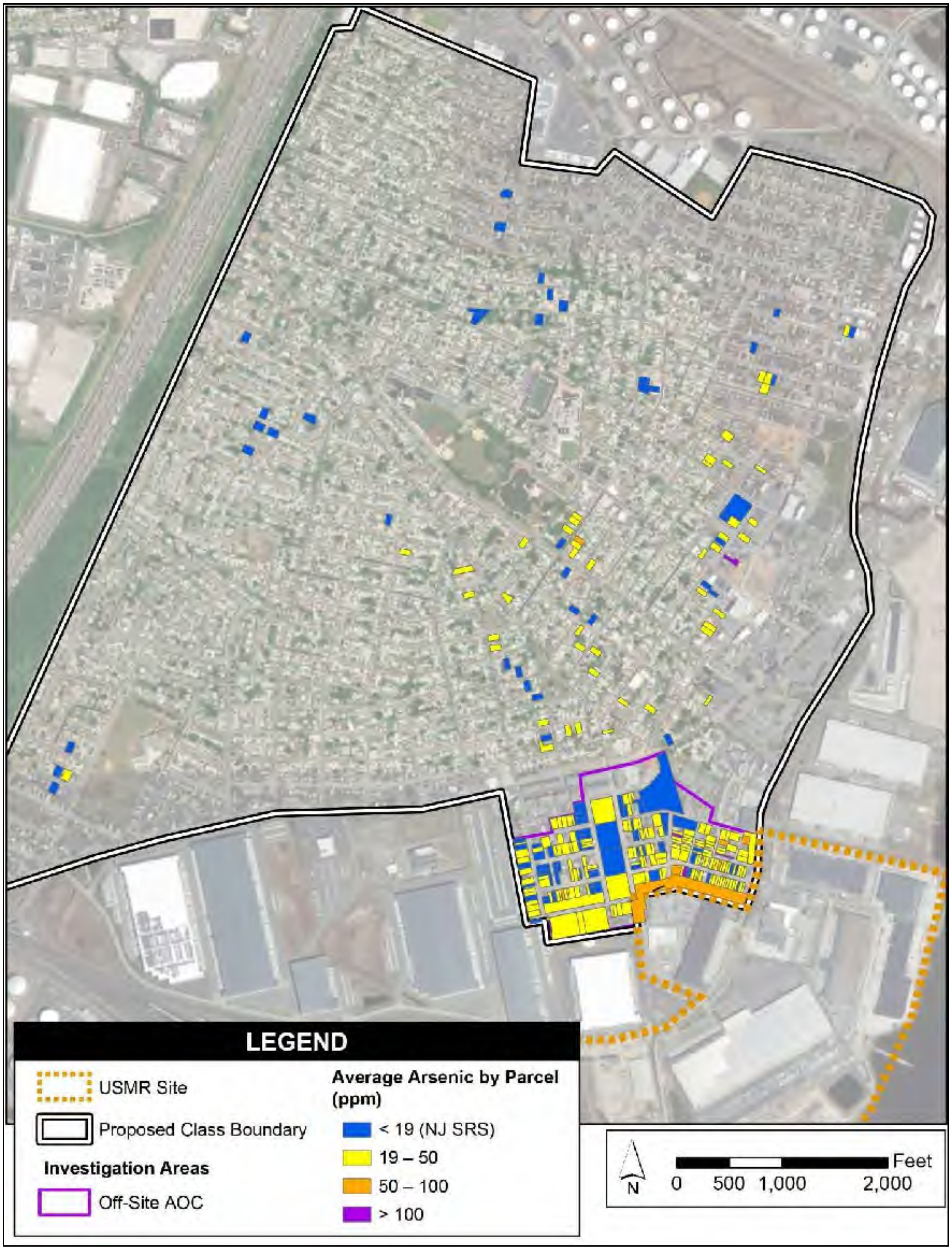

Figure 5-4. Average Arsenic by Parcel

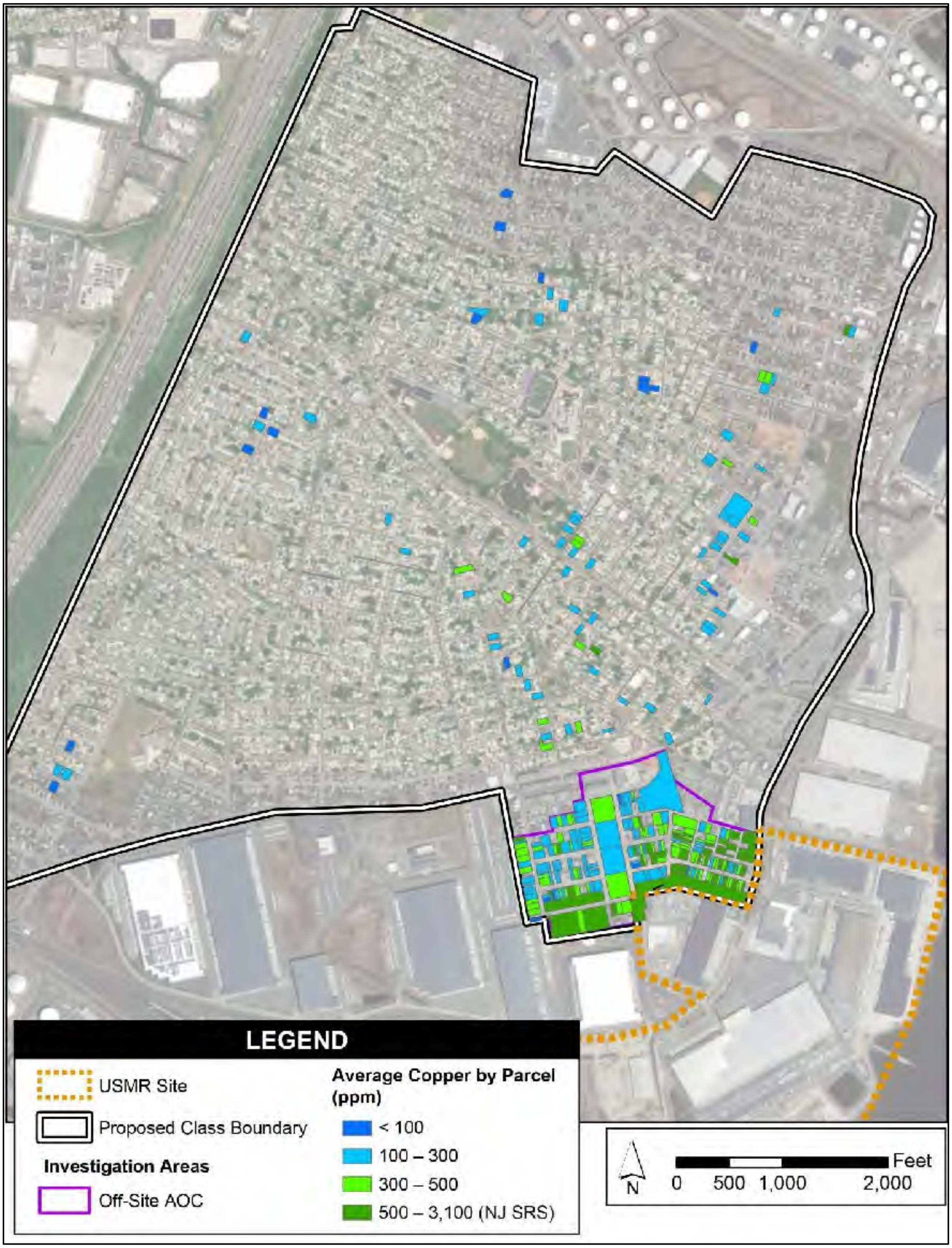

Figure 5-5. Average Copper by Parcel

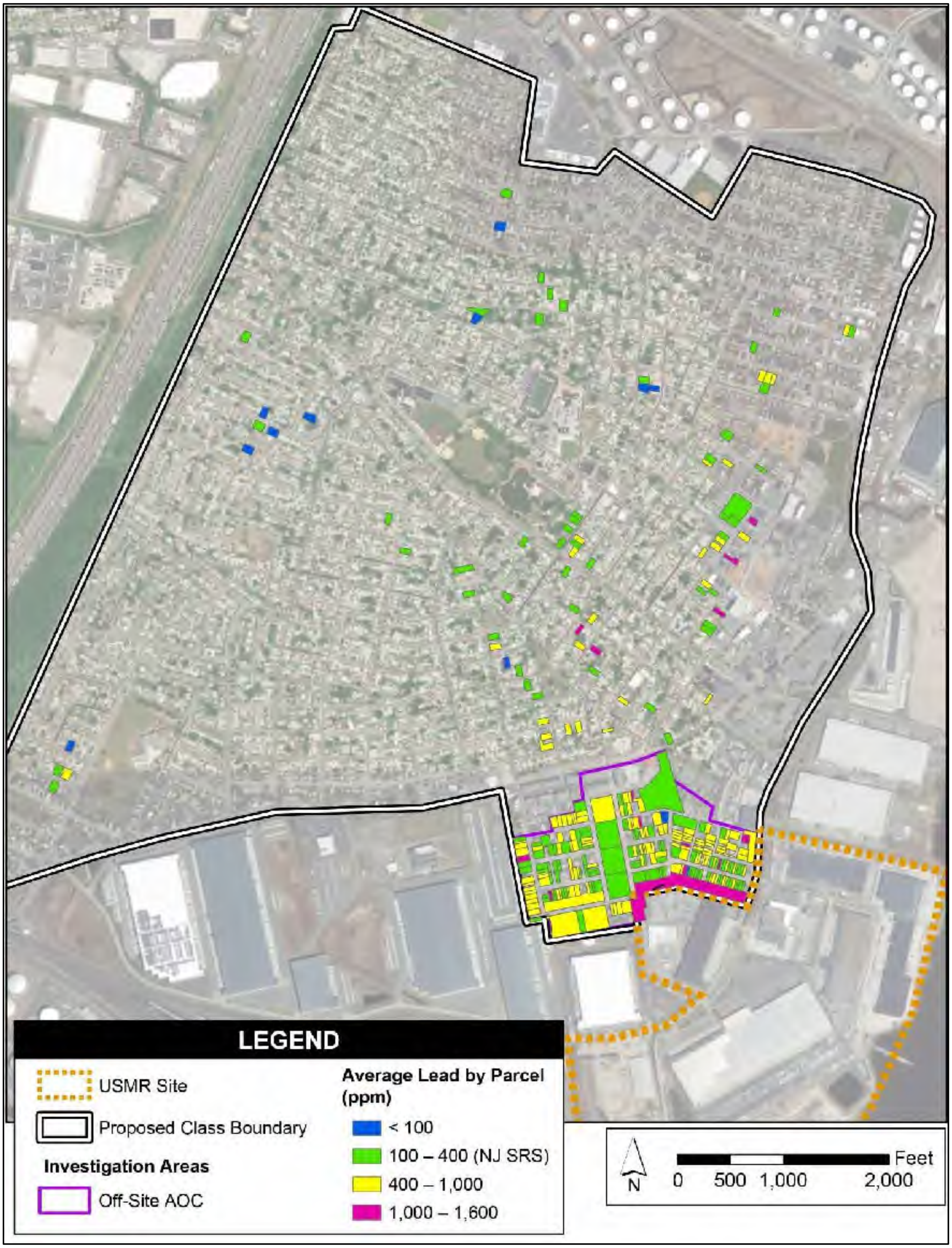

Figure 5-6. Average Lead by Parcel

6.0. Opinion 2 – No Analytical Relationship Between Carteret Soil Metals and USMR

Statistical analysis of the data demonstrates that there is no discernable trend or pattern outside of the immediate vicinity of the former USMR facility that can be attributed to a single source. Specifically, the USMR transect data and Plaintiffs' data display patterns and trends that cannot be attributed to USMR.

6.1 Description

In his report, Dr. Shahrokh Rouhani utilized four lines of evidence to evaluate the extent of potential impacts from the former USMR facility within the proposed class area. The four lines of evidence evaluated include:

1. Chemical fingerprints,
2. Background analysis,
3. Trend analysis, and
4. Geostatistical (Variogram) analysis

Each line of evidence is summarized below.

6.2 Chemical Fingerprints

Chemical fingerprints, or signatures, are often used to differentiate between sources in soils impacted by metals. Ratios of metals tend to be more resistant to changes over time and space than concentrations and thus the effects of dilution and redistribution are mitigated.[60] Ratios of soil metal concentrations collected from the former USMR site can be used to establish a signature for USMR impacts, which can then be compared to ratios of the data collected from the AOC, the USMR transect data, and the plaintiff dataset. A comparison of these metals ratios shows that samples from the site are dominated by copper (60%) with lesser components of lead (37%) and arsenic (approximately 5%). As distance of sample locations from the former USMR site increases, the ratio of copper decreases and lead increases. With increasing distance from USMR the percentage of copper to the total of the three metals declines from 60% to 37% in the transect samples while lead increases from 37% to approximately 60% (Figure 6-1).[61] If USMR was the source of these metals, the ratios would remain consistent with distance.

[60] Rouhani, 2019. Pg. 8/105.
[61] Rouhani, 2019. Pg. 10/105.

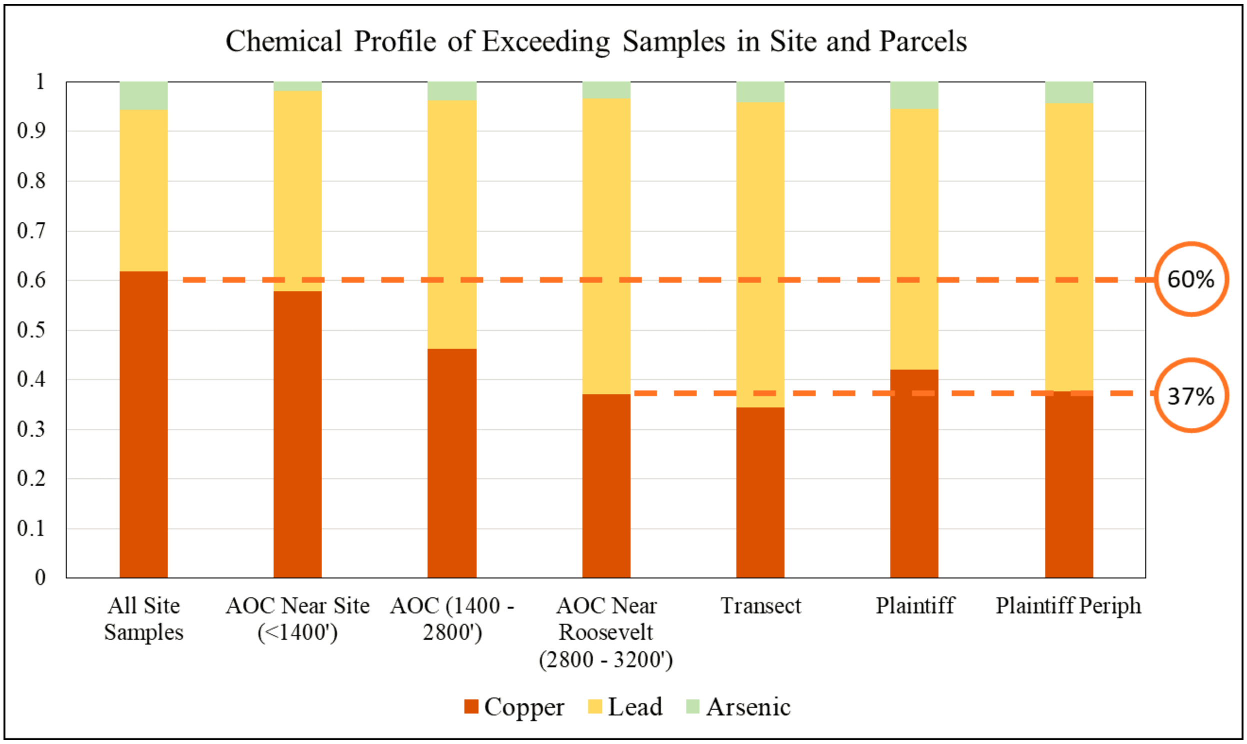

Figure 6-1. Chemical Profiles (Figure 4 in Rouhani report)

6.3 Background Analysis

Arsenic, copper, and lead are all naturally occurring metals that can be found in unimpacted, background soils. Thus, to determine impacts from the USMR Site, one must distinguish between the concentrations associated with background and those related to a release from the USMR site.[62] To distinguish between these concentrations, Dr. Rouhani conducted a probability plot analysis to extract background information from the full, site-wide soils database. After extracting the background dataset, a 95% upper tolerance limit with 95% coverage (95-95 UTL) can be calculated to represent background conditions in the proposed class area. Lastly, the calculated 95-95 UTLs were compared to NJDEP's published background levels for the Urban Piedmont region of New Jersey.

Table 6-1 shows the summary statistics of the offsite background dataset and the NJDEP Urban Piedmont dataset.[63] The calculated 95-95 UTLs and background maximums for arsenic and lead for the proposed class area are lower than those of the NJDEP background dataset. The background levels for copper, however, are higher within the proposed class area. This difference can be attributed to the prevalence of potato farming and the historical use of agricultural chemicals containing copper throughout the proposed class area prior to residential development (see section 8.0).

[62] Rouhani, 2019. Pg. 16/105.
[63] Rouhani, 2019. Pg. 17/105.

Table 6-1. Summary Statistics of Background Datasets (Table 2 in Rouhani Report)

Extracted Offsite Background Data										
Constituent	Count	**Average**	Median	Minimum	Maximum	90%-tile	95%-tile	99%-tile	**95-95 UTL**	Distribution
Arsenic	18326	**12.4**	10.8	0.02	26.9	22.8	24.7	26.5	**24.9**	nonparametric
Lead	14623	**96.6**	74.5	0.07	278.0	224.0	250.0	271.8	**252.0**	nonparametric
Copper	16641	**114.4**	90.9	0.09	324.0	263.0	293.0	318.0	**294.0**	nonparametric
NJDEP Urban Piedmont - 1997										
Constituent	Count	**Average**	Median	Minimum	Maximum	90%-tile	95%-tile	99%-tile	**95-95 UTL**	Distribution
Arsenic	67	**10.0**	5.2	1.7	49.7	24.2	29.5	49.1	**48.8**	nonparametric
Lead	67	**138.9**	111	14.9	464	271.7	332.0	465.9	**392.1**	Gamma
Copper	67	**38.7**	29.5	9.3	139	71.1	90.0	139.9	**112.8**	LogNormal

After determining the background threshold values (BTVs) for the three investigated metals, the rate of exceeding samples for each metal was plotted versus distance from the former USMR smelter stack (Figure 6-2).[64] The resulting trend chart shows that within 1,800 feet of the former smelter stack, copper dominated with between 60-95% of the samples collected exceeding the BTV for copper. Between approximately 1,800 feet and 3,000 feet from the former smelter stack, the pattern transitions as the copper exceedance rates decline and lead exceedance rates remain steady. Past 3,000 feet, lead emerges as the primary metal exceeding background with copper exceedance rates approaching zero. These patterns are not consistent with impacts from the USMR site.

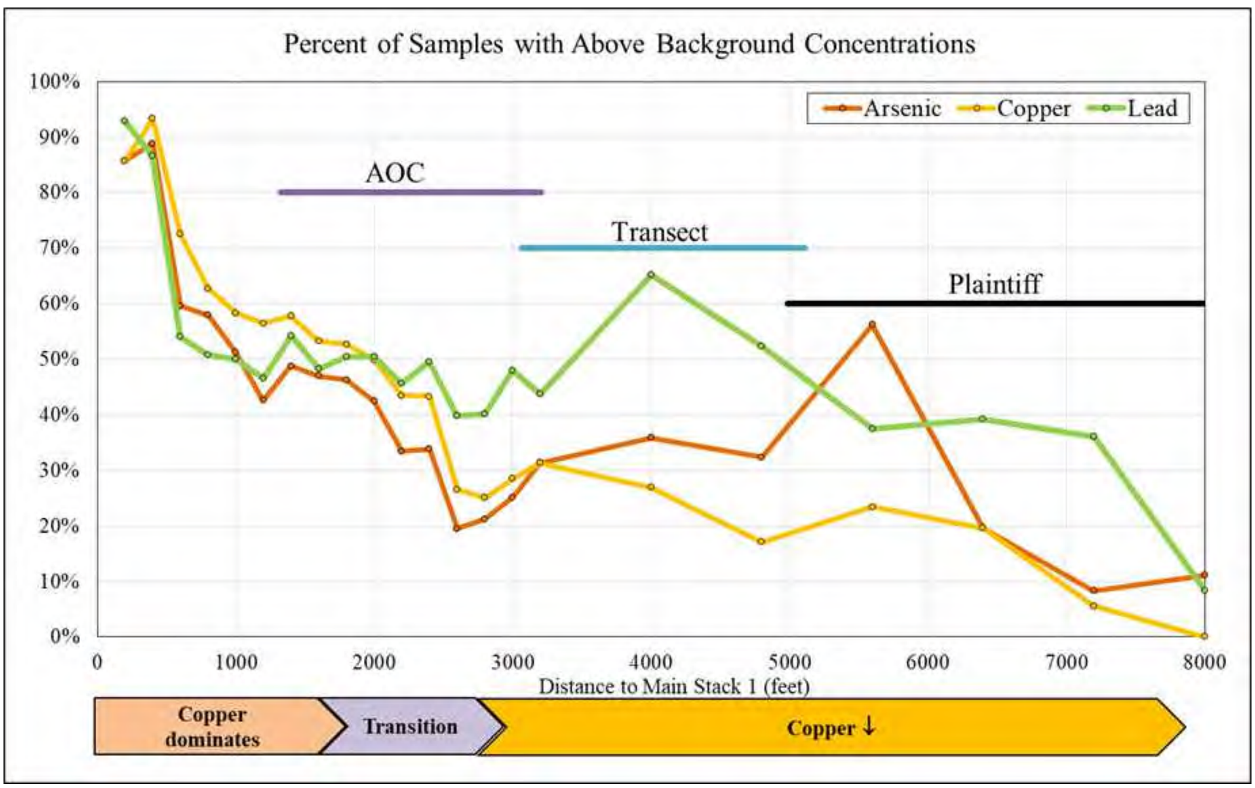

Figure 6-2. Percent of samples with Above Background Concentrations (Figure 10 in Rouhani Report).

[64] Rouhani, 2019. Pg. 18/105.

6.4 Trend Analysis

Impacts from air emissions from a point source should result in an exponential decreasing concentration trend from the original source (i.e. stack) in surficial soils.[65] Thus, trends in surface soil samples can be used to evaluate potential impacts from the former USMR site. Concentration trends for each metal are shown in Figures 6-3 – 6-5, with the exponential trend line shown for the AOC samples.[66] The charts show that for all three metals, concentrations within the AOC show a decreasing trend but the data outside of the AOC and north of Roosevelt Avenue do not display trends consistent with the AOC trends and thus cannot be attributed to air-related impacts from the Site.[67]

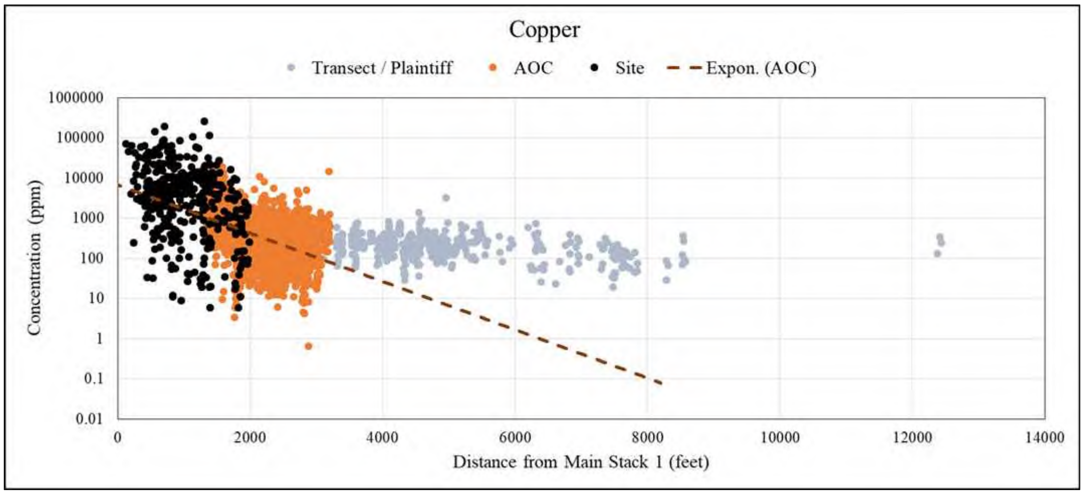

Figure 6-3. Copper Trend (Figure 12a in Rouhani Report)

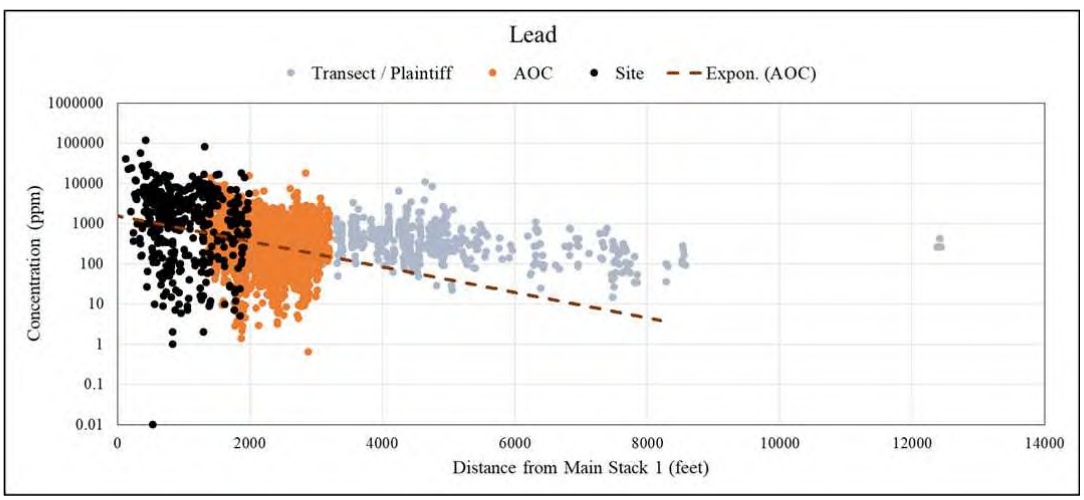

Figure 6-4. Lead trend (Figure 12b in Rouhani Report)

[65] Rouhani, 2019. Pg. 20/105.
[66] Because the Y-axis is shown in log scale, the exponential trend line plots as a straight line
[67] Rouhani, 2019. Pg. 21-22/105.

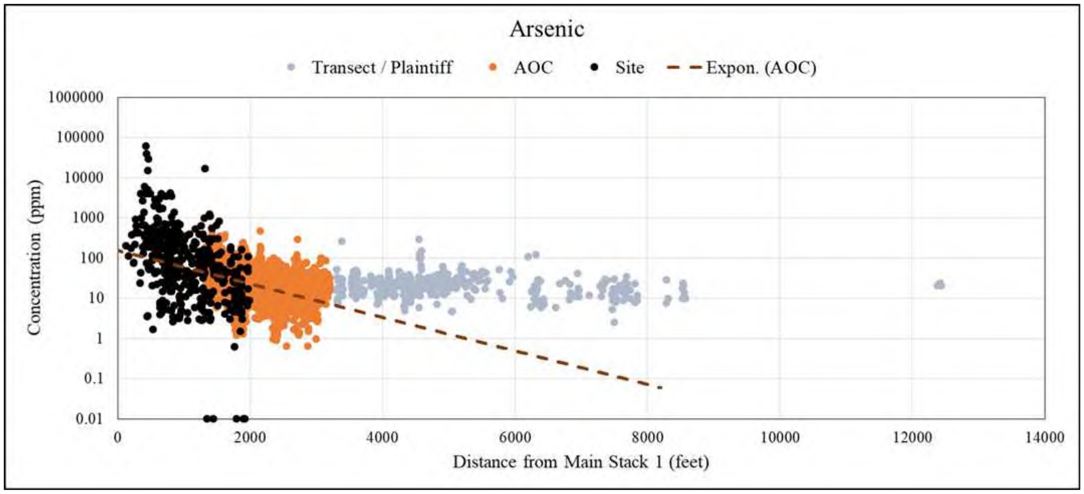

Figure 6-5. Arsenic trend (Figure 12c in Rouhani Report)

6.5 Variogram Analysis

Variography is a common measure of spatial correlation and represents the spatial variability between paired samples with various separation distances and directions.[68] Variograms can illustrate four different spatial patterns: trend, structured, hotspot, or noise (Figure 6-6).[69] In other words, variography can reveal if the data is showing directionality, i.e. whether there is a discernable relationship or trend between the location and concentration of the data points. Plaintiffs' conceptual site model is based on the deposition of airborne particulates, which would produce decreasing concentrations with distance from the former USMR facility. The Plaintiffs' conceptual site model would produce variograms that show a 'trend' pattern as illustrated below originating at the former USMR facility.

[68] Rouhani, 2019. Pg. 25/105.
[69] Rouhani, 2019. Pg. 25-26/105.

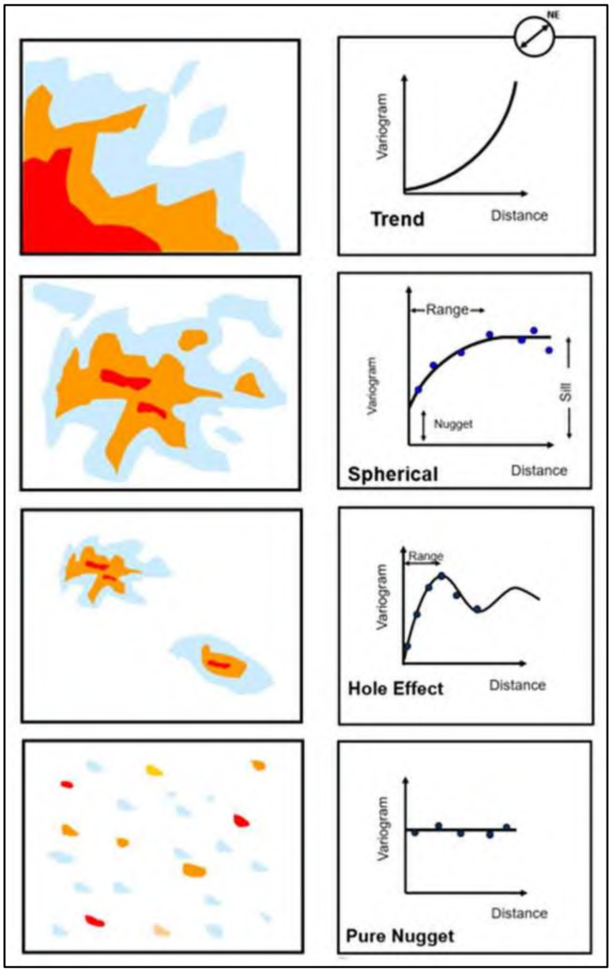

Figure 6-6. Typical Variogram Results (Figure 14 in Rouhani Report)

Variograms were developed for each metal for the AOC data and for the USMR transect and plaintiff transect data. The variograms of **AOC** data all display a trend towards the Site, while the variograms of the USMR and plaintiff **transect** data display hole-effect patterns. Such a pattern is indicative of isolated hot spots with no spatial relationship to the former USMR facility.[70] This suggests that, outside of the AOC, the soil metals concentrations do not have a pattern related to distance from the former USMR facility but instead represent more localized area or parcel-specific sources. The Plaintiffs' air deposition conceptual site model is not supported by the variography analysis. All of the variograms are provided in Appendix 4 to Rouhani's report and two are provided below as examples (Figures 6-7 – 6-8).

[70] Rouhani, 2019. Pg. 28/105.

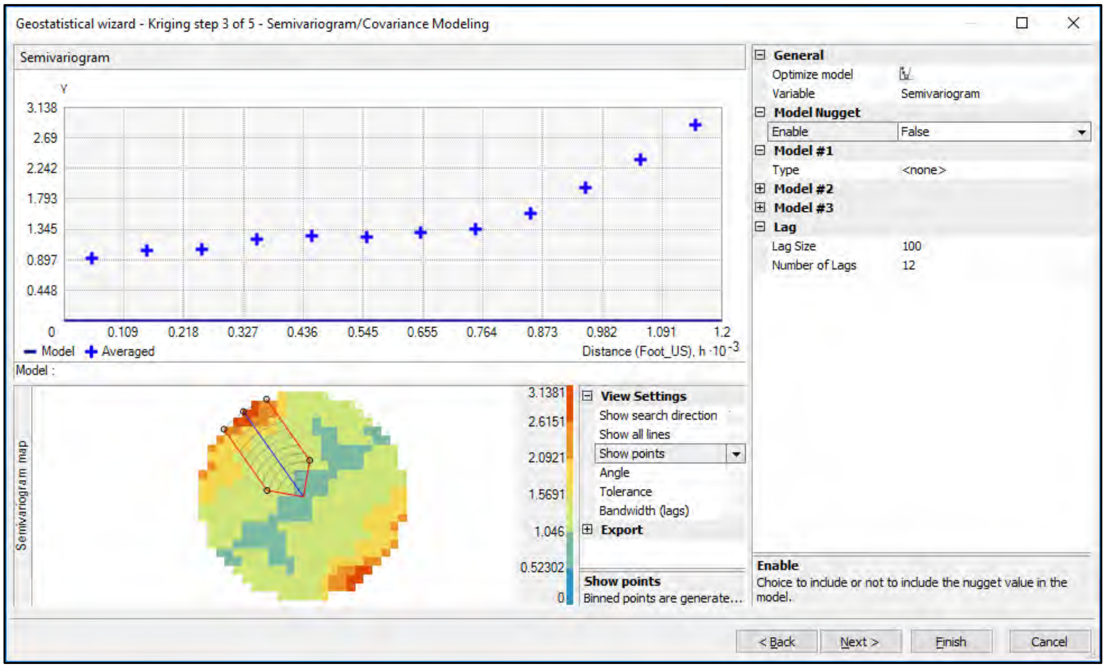

Figure 6-7. Directional variogram of AOC Surface Soil Copper Data (Figure 15 in Rouhani Report).

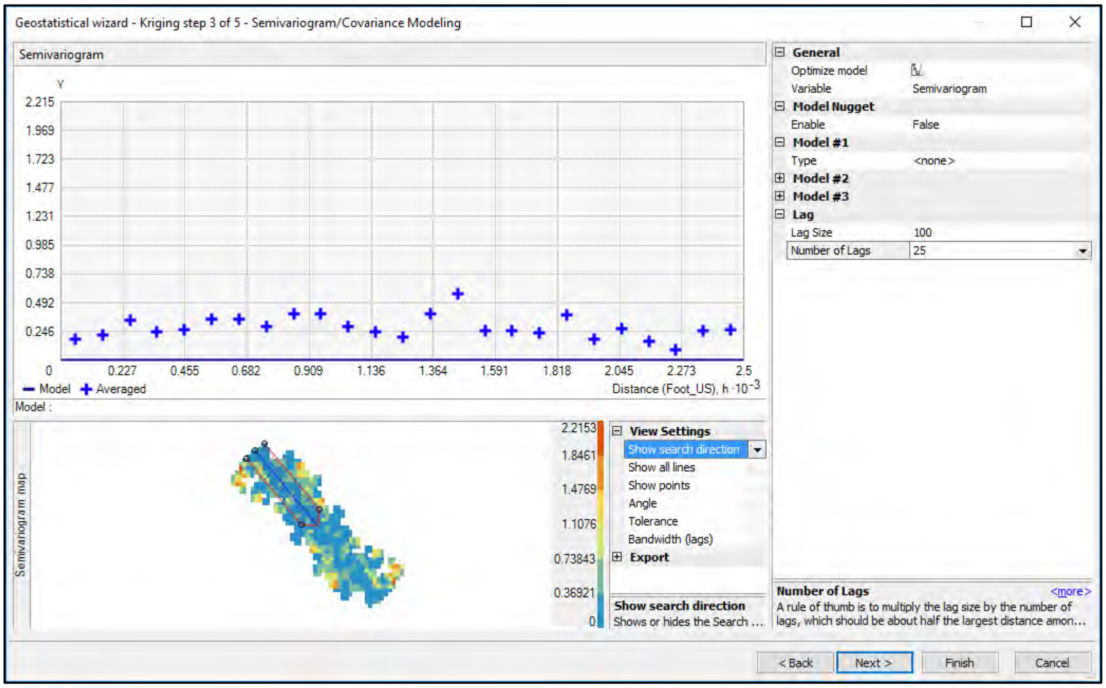

Figure 6-8. Directional Variogram of Surface Soil Copper Data (Figure 16 in Rouhani Report).

6.6 Vetted Dataset Analysis

In his report, Dr. Rouhani identifies the presence of several confounding factors that "can obscure patterns of Site impacts within adjacent parcels."[71] These confounding factors include[72]:

- The widespread presence of non-native fill materials
- Altered parcels (parcels that were previously developed but are currently vacant or properties that were developed after USMR operations ceased)
- Soil turnover at vacant parcels or properties that had structures during the majority of USMR operations
- Potential specific areas heavily impacted by fill

In order to ensure these confounding factors do not obscure patterns associated with possible impacts from the USMR site, Dr. Rouhani created a 'vetted' soil dataset of off-site soil samples that minimize the effects of these confounding factors and replicated all of the analyses discussed above with this vetted dataset. His conclusions based on the vetted dataset are summarized below.

- The vetted dataset represents 5% of the exceeding off-site soil samples, which implies that the vast majority of exceeding off-site samples are impacted by factors unrelated to air emissions from USMR.[73]
- The vetted dataset confirms the findings from the chemical fingerprint analysis discussed in Section 6.2 that off-site exceeding samples are dominated by lead and are not consistent with impacts from the USMR site.[74]
- The vetted dataset confirms the findings from the background analysis discussed in Section 6.3 which shows the above-background trends outside of the AOC are inconsistent with potential impacts from the USMR site.[75]
- The vetted dataset confirms the findings from the trend analysis discussed in Section 6.4 that the trends observed outside of the AOC are not consistent with the trends observed within the AOC.[76]
- The vetted dataset confirms the findings from the variogram analysis discussed in Section 6.5 with two primary observations:
    - The data outside of the AOC display the presence of isolated hotspots with no spatial connection to the USMR site,[77] and
    - The trends observed in the variograms within the AOC are most likely the result of the presence of fill materials throughout the AOC.[78]

[71] Rouhani, 2019. Pg. 12/105.
[72] Rouhani, 2019. Pg. 12-13/105.
[73] Rouhani, 2019. Pg. 13/105.
[74] Rouhani, 2019. Pg. 14/105.
[75] Rouhani, 2019. Pg. 19/105.
[76] Rouhani, 2019. Pg. 23/105.
[77] Rouhani, 2019. Pg. 30/105.
[78] Rouhani, 2019. Pg. 30/105.

In summary, each of the four statistical methodologies employed by Dr. Rouhani reached the same conclusion: sample results outside of the AOC display patterns and trends that cannot be attributed to the former USMR facility.

7.0. Opinion 3 – Parcel-specific Activities Created Highly Localized Metals Variability

Activities unrelated to the former USMR facility contributed to the mass of arsenic, copper, and lead and created localized elevated concentrations of metals that can only be understood by detailed parcel-specific assessment and cannot be reliably assessed on a class-wide basis. Specifically, evaluation of the vertical and spatial pattern of metals concentrations, historical land use and residential development, historical homeowner activities, low-lying topography and extensive use of non-native fill indicate that metals encountered in the area are a consequence of many anthropogenic activities, including agricultural, industrial, and residential sources.

7.1 Opinion 3-1: Metals were Intentionally Used on Parcels by Property Owners

A prevalent direct relationship exists between property-specific characteristics and property owner activities and metals concentrations.

This set of opinions addresses the pattern of metals in soils in the proposed class area and the correlation of the presence of those metals with housing stock characteristics, past land use, and property-specific activities independent of the former USMR facility as a point source for metals air transport.

7.1.1 Opinion 3-1A – Lead-based Paint Parcel Specific Characteristics

For residential properties within the proposed class area, a prevalent direct relationship exists between lead and the age and size of homes. Several lines of evidence demonstrate that LBP is the most likely common factor creating this correlation including: (i) extensive literature describing the relationship between housing age and the extent of painted surface with soil impacts from LBP; (ii) visual observations and data regarding housing age, construction type, and conditions in Carteret; (iii) soil chemical analysis and related spatial patterns; and (iv) microscopic analysis positively identifying the presence of LBP in Carteret soils. The quantity and characteristics of lead on each property is unique to each property in accordance with the specific variables of age and size of home and homeowner home maintenance practices.

7.1.1.1 General

Lead-based paint is a significant and highly parcel specific source for a community such as Carteret in which the housing stock almost entirely predates 1960. LBP is also a source that can be examined parametrically and geospatially by examining the relationship between the quantity of lead in the soil of a given parcel and characteristics of the housing stock.

The hypothesis being tested is whether soil lead (or any metal) is present due to a property specific source, is predictable based on property specific characteristics, and is independent of spatial relationship to the former USMR facility stack.

This section provides an analysis of the pattern of lead contamination relative to distance from the former USMR facility and housing stock characteristics. This analysis includes a review of the range of potential loading of lead from LBP into the Carteret community prior to the banning of LBP for residential use in 1978.

7.1.1.2 Lead-based Paint Characterization

An extensive assessment of LBP provided by A.H. Sabin in 1919 and 1920 provides a background on the characteristics of lead-based paint in the first half of the 20th century. Several passages from Sabin's work are instructive.

> *"Many years ago engineering opinion seems to have settled on the proportion of thirty-three pounds of red-lead to a gallon of oil; such paint contains 22.57 pounds of red-lead and 5.3 pounds oil in a gallon of paint."*

This yields a total weight per gallon of paint of approximately 28 pounds. For white lead paint, the content of lead was reported by Sabin as having a weight per gallon of 21.5 pounds:

> *"It takes sixteen pounds of white-lead and five and half pounds of oil to make a gallon of paint…"*

Sabin added that LBP could potentially weigh over 30 pounds per gallon with the dry pigment or solids weighing as much as 26 pounds per gallon. Red-lead LBP is denser than white-lead LBP, but both could weigh more than 25 pounds per gallon. Although white-lead LBP was more common as house paint, red-lead LBP could be used as primer coat.[79] Red-lead paint would likely have also been used on any outdoor metal surfaces, such as railings or metal equipment. It would also have been more common in industrial or commercial facilities for painting large outdoor surfaces, including tanks and equipment.

Red lead is an oxide in which the overwhelming proportion of the solid, by weight, is lead. White lead is a carbonate with a somewhat lower proportion of the paste as lead, but the proportion by weight is still mainly lead.

Paint consists of a variety of constituents, principally the oils used as the mixing agent and the pigments. The pigments themselves are made up of individual components such as metals, carbonates, or oxides. The carriers were typically linseed oil or turpentine, or a mixture of these with other oils to optimize cost and functionality. Further, the dried paint had a separate composition, becoming a mixture of remaining film from the oils and the combination of pigment compounds. Each of these constituents and mixtures has a separate specific gravity. As detailed in Appendix A, LBP could contain anywhere from 13 to 25 pounds of lead per gallon.

The carriers and oils discussed in the previous paragraph eventually degrade over time which results in the 'chalking' of LBP. In his 1920 book, Sabin states that white lead chalks because the oil decomposes, especially when exposed to sunlight:

> "When pure white-lead…is exposed to direct sunlight, after a time which sometimes is one year and sometimes two or three it loses the oil, the outer part of the film, leaving the lead without any binder and this loose lead- not the whole of it but just the surface, will brush or rub off as chalk may be rubbed off a blackboard… that is the white-lead perishes, gradually from the surface, without injury to the under layers until the outer layers are worn off."[80]

The chalking of LBP was described as a benefit. In a 1919 article, E.V. Peters stated that "when a white lead paint coat fails it does so by gradually and progressively crumbling to powder, a process called

[79] Sabin 1920, pg. 128/169.
[80] Sabin 1920, pg. 73-74/169.

'chalking'. The powder 'chalk' weathers off and a fresh surface is presented, which in turn powders. A chalking paint presents an even surface for repainting." Additionally, an article published in the Carteret Press on April 27, 1956 discussing titanium-lead zinc paints states that such a paint "ages gracefully and leaves a sound surface for repainting."[81] The article goes on to state that these paints "chalk freely and remain uniformly white and clean."[82] As a result of chalking, LBP will contribute lead to nearby soils even without peeling or flaking paint.

7.1.1.3 Consequences of LBP in Soils in Carteret

According to Clark and Knudson (2014)[83], the two main sources of lead in the urban residential environment are combustion of leaded gasoline and deterioration of paints. According to Clark and Knudsen, the steep decline of the use of lead in house paints began in the post-World War II housing boom, or the late 1940s and early 1950s.

> *"The use of Pb as a paint additive peaked in the 1920s, before advocacy and legislative efforts during the post-WWII housing boom led to a steep decline in the use of Pb in house paints (Laidlaw and Filippelli, 2008). These efforts became final with the complete ban of Pb in house paints by the U.S. Consumer Product Safety Commission in 1978. Clark et al. (1991) estimated that between 1932 and 1980, nearly 7 million tons of Pb were used in the production of white paint in the United States. "*

The soil lead concentration distribution patterns observed from the sampling in Carteret are similar to those found in Appleton, WI by Clark and Knudson. Importantly, the vicinity around the Appleton study area did not contain a large industrial source, such as a smelter, but the soil lead distribution patterns and lead concentrations in Appleton still closely resembled those observed for Carteret residential properties. The study focused on an older neighborhood in Appleton with housing traits similar to those of Carteret: approximately 40% of the homes were constructed pre-1900, while 85% were constructed pre-1950. In their study, three surface soil samples were collected from properties; one at the dripline, one at the mid-point of the yard, and one at the terrace (the grassy strip between the street and the sidewalk). In their study, Clark and Knudsen identified LBP as a primary source of lead in a small-urban residential setting. The study found a range in soil lead concentrations between 47 – 32,483 ppm.[84] Additionally, they found a significant difference in lead levels between houses constructed pre-1960 and post-1960. [85]

Clark and Knudsen found that more than two-thirds of the dripline samples exceeded 400 ppm for lead, and one-third exceeded 1,200 ppm. Nevertheless, lead contamination from LBP was not limited to the dripline. Approximately 40% of the yard space exceeded 400 ppm for lead. The maximum mid-lawn samples exceeded 3,000 ppm with concentrations typically exceeding 400 ppm several meters into the yard around all sides of the home.[86] Where homes are close to one another (like they are in most of Carteret), concentrations tended to remain high even into the mid-lawn area. The authors concluded:

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[81] Carteret Press, 1956. Pg. 2/10.
[82] Ibid.
[83] Clark and Knudson, 2014. Pg. 1/9.
[84] Clark and Knudson, 2014. Pg. 4/9.
[85] Clark and Knudson, 2014. Pg. 4/9.
[86] Clark and Knudson, 2014. Pg. 5/9.

> "Our study area is not exceptional, and the trends we report here are likely to be similar in smaller urban residential communities across the country. We show that the best predictor of contamination is the age of structure, with those built before 1960 returning significantly higher SLL [soil lead levels]"[87]

Similar to the Appleton, WI study, a study of lead concentrations in Baltimore, Maryland found that, despite high variability of soil lead concentrations, housing age, the distance to painted structures, and distance to a major roadway are strong predictors of soil lead concentrations.[88] The Baltimore study found lead soil concentrations ranging from 7 ppm to 9,151 ppm, with 22% of the sampled parcels exceeding 400 ppm for lead.[89] The study identified LBP and leaded gasoline as the sources of lead in soils and stated that "both sources have contributed to widespread soil lead pollution in Baltimore even after more than two decades of restrictions on both sources."[90]

As identified in the studies by Clark and Knudson and Schwarz et al., LBP is a potential source that can be examined for correlation with property conditions (e.g. age and house characteristics). The first requirement is the determination of what factors are appropriate for examination of potential correlation between metals concentrations and property conditions. Similar to the quote from Clark and Knudson above that "the best predictor of contamination is the age of structure," HUD states that:

> *"Lead was a major ingredient in most interior and exterior oil house paints prior to 1950..."[91]*

The age, size of the house, and materials of construction for a structure affects the quantity of paint used over time. The larger the home, the more paint that must be used during each painting cycle. The older the home, the more painting events that occurred and the greater the opportunity for chalking, peeling, and scraping of material that could be transported intentionally or unintentionally into the surrounding soils. The earlier a home was constructed, the more likely that the paint contained lead, both for interior and exterior uses. In addition, the quantity of lead within a gallon of paint was greater in earlier years, particularly before the 1940s. For exterior uses, a wood frame house that is repainted as often as every five years, will require more paint on the exterior than a brick veneer home. However, even brick veneer homes were often painted.

Scientific literature describes the correlation of housing age to lead-based paint use:

> *"Age of housing is recognized as a surrogate for Pb-based paint. The peak use of Pb in paint occurred in the mid-1920s decreased rapidly by the late 1940's, and then declined slowly until its ban for residential use in 1978."[92]*

According to Jan Gooch's Lead Based Paint Handbook, although the use of LBP originally peaked by the early 1930s, use rebounded in the late 1930s and early 1940s when the lead industry re-doubled its efforts to promote white lead for paint.[93] Gooch also observed "although in the 1950s, interior house

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[87] Clark and Knudson, 2014. Pg. 8/9.
[88] Schwarz, et al. 2016. Pg. 1/14.
[89] Schwarz, et al. 2016. Pg. 4/14.
[90] Schwarz, et al. 2016. Pg. 7/14.
[91] Reich, 1992; Rabin, 1989
[92] Mielke et al., 1999
[93] Gooch, 1993. Pg. 95.

paints declined in their lead content, high-volume leaded house paint was sold without proper labeling and used on interior surfaces."[94]

The prevalence of LBP and the relevance of its changing use over time is demonstrated by the results of the 1995 Report on the National Survey of Lead-Based Paint in Housing, Base Report.[95] The sampling included in the report was conducted in 1989 and 1990. Twelve years after LBP was banned for residential use, an estimated 76% (± 12%) of the housing units built between 1960 and 1979 had lead-contaminated paint on their surfaces. The percentage increased to 90% (± 8%) for homes built before 1960. This is an indication that the use of LBP was widespread even after the 1950s.

In order to assess the contribution of LBP to lead soil mass in the Carteret area, a probabilistic estimate was developed of the potential range of the total mass of lead brought onto properties by property owners through LBP relative to the lead mass in soils for four example properties. These four properties were chosen from the USMR-sampled transect properties because of the availability of detailed data[96] on the housing characteristics and the concentrations of lead within the property soils. In addition, the properties are located outside of the area that the geostatistical analysis suggest could have any potential relationship to the former USMR facility.

First, the pounds of lead within the soils for each USMR transect property within the top one foot of soil is shown in Table 7-1. Estimates are provided for the pounds of lead, and the incremental pounds of lead above the midpoint estimate of the background range (see section 6.3). The incremental values provide a better estimate of the quantity of lead on the property that may be present due to a local anthropogenic source beyond natural background and/or regional sources such as leaded gasoline or general urban air deposition. Table 7-1 shows that the mass of lead varies widely from property to property. That variation is inconsistent with an air deposition pathway which would produce a more uniform loading for similarly located properties, and instead suggests property-specific factors are driving the lead content of the individual properties.

[94] Gooch, 1993. Pg. 95.
[95] USEPA, 1995. Pg. 16/46
[96] Plaintiffs' samples were not used in this LBP mass balance analysis because there were insufficient borings (2-3 compared to 10 for USMR) to characterize the total mass of lead in the soil layer.

Table 7-1- Pounds of Lead in Soils at USMR transect Properties

PPIN	Year Built	Lead in Top Foot of Soil Based on Average Concentration (lbs.)	Lead in Top Foot of Soil Above Mid-Range Background Estimate (139 ppm) (lbs.)	Average Distance of Samples from Stack (ft)
6015	1944	17.31	3.47	3,077
7015	1900	59.00	44.42	3,315
6105	1948	24.76	9.59	3,382
6020	1905	32.53	23.22	3,386
6202	1912	48.77	37.39	3,547
5287	1910	142.09	119.80	3,552
5285	1939	40.03	26.86	3,597
5271	1914	143.34	117.50	3,615
5269	1942	47.24	36.37	3,708
5368	1924	98.11	76.83	3,834
7205	1912	27.91	16.43	3,932
7206	1910	28.08	15.74	3,964
6419	1920	17.53	9.59	3,971
5461	1952	23.08	6.01	4,045
7209	1910	76.39	67.00	4,084
6408	1900	56.27	49.48	4,097
5457	1953	22.14	3.18	4,171
6514	1902	114.06	96.16	4,260
7310	1902	33.67	20.16	4,320
7319	1900	10.57	5.56	4,339
6508	1907	151.10	131.79	4,368
5553	1953	27.08	3.35	4,376
6522	1914	79.77	60.87	4,430
5544	1953	17.97	0.00	4,471
6632	1940	38.16	12.42	4,554
7337	1908	165.62	145.06	4,572
5631	1953	272.06	236.87	4,674
7401	1918	52.83	38.32	4,715
7412	1917	71.98	59.29	4,744
5633	1953	43.89	19.62	4,768
7410	1900	31.78	22.65	4,798
7350	1900	16.55	11.80	4,812
7409	1918	38.28	20.68	4,836
6643	1949	12.56	2.00	4,894
6716	1941	42.88	25.90	4,926
7355	1900	98.55	86.01	4,945
7416	1924	6.09	2.12	4,986
6723	1941	65.87	43.92	5,092

An estimate was then developed of the range of lead that could have been brought onto the properties through LBP for four example properties. The mass of lead that was potentially brought onto a particular property through LBP is a function of the years the home existed before 1978, the size of the home, the square footage of painted surface, and the number of painting cycles. Thus, this analysis requires the assimilation of a large amount of site-specific data.

Year of construction data was obtained from the Middlesex County tax parcel dataset through the New Jersey Geographic Information Network. Information on residence size was obtained from Zillow. Figure 7-1 illustrates the ages of individual homes with an overlay that groups housing with similar ages. This provides an illustration of the temporal development pattern of Carteret over the last century.

For the four example properties, street-level Google StreetView imagery as well as aerial imagery were utilized to determine several property-specific characteristics, including the amount of exterior painted surface, the number of windows at the property, the number of stories of the structure, the presence and size of porches, and the presence of outbuildings/garages.

The estimate of the range of LBP brought onto the properties is probabilistic as described in Appendix A. The comparison of the median estimate of the range of the pounds of lead that could be associated with LBP, from Appendix A, with the lead present in the soils on the four properties assessed is shown on Table 7-2.

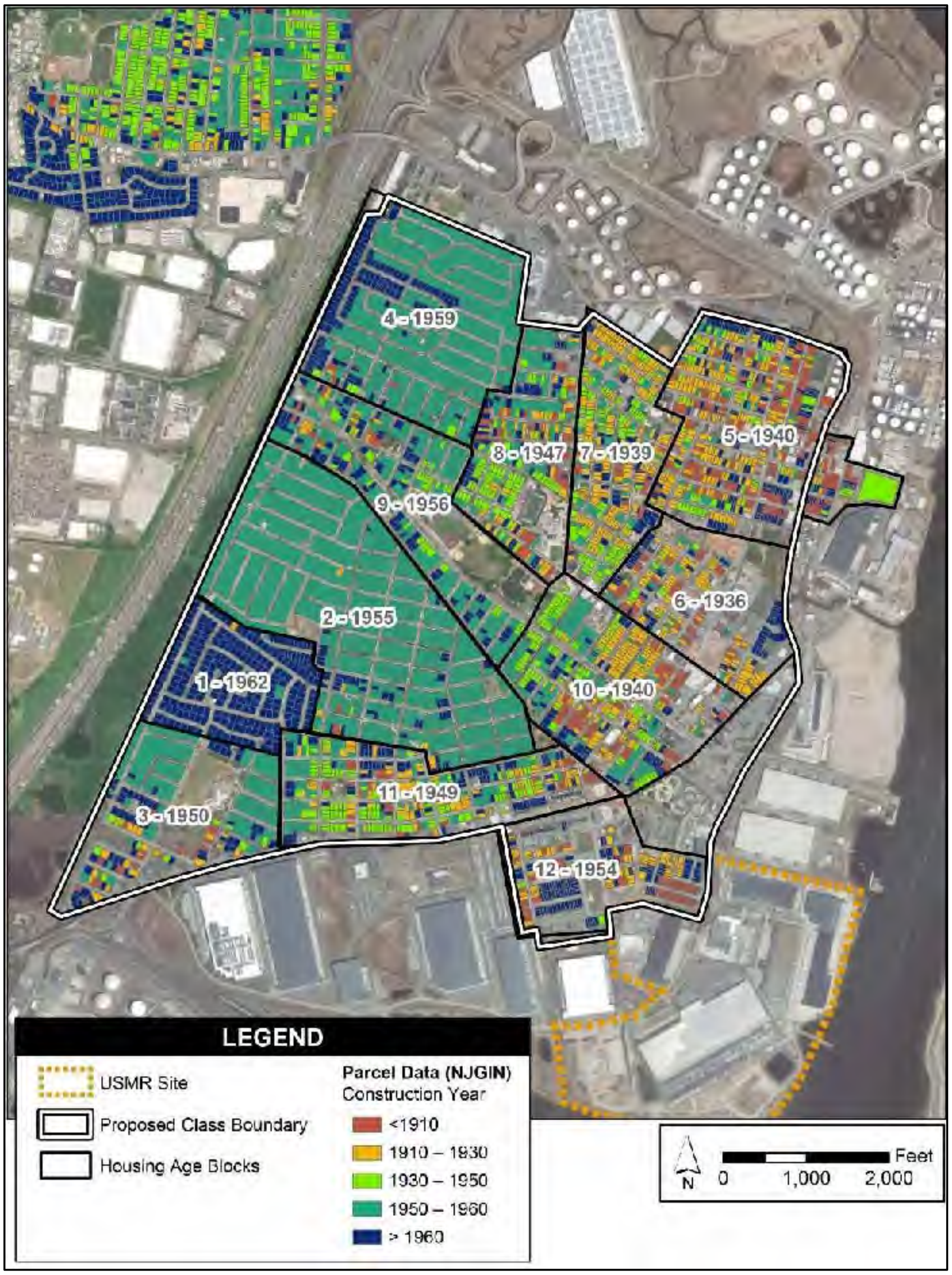

Figure 7-1. Housing Age Blocks

Table 7-2. Comparison of Estimates of Lead from LBP and Soil Lead By Parcel

PPIN	Median Estimate of Potential Lead from LBP Applied on Property (lbs.)	Lead in Top Foot of Soil Based on Average Concentration (lbs.)	Lead in Top Foot of Soil Above Mid-Range Background Estimate (139 ppm) (lbs.)	Incremental Soil Lead / Lead in LBP Potentially Used on Property (%)
5271	1275.0	143.3	117.5	9.2%
5368	563.0	98.1	77.0	13.7%
6643	271.0	12.6	2.0	0.7%
7350	2125.0	16.6	11.8	0.6%

The following observations are derived from Tables 7-1 and 7-2 and demonstrated graphically in Figure 7-2:

1) The lead in the soil can be accounted for from the use of LBP. The lead in the soil is a relatively small percentage of the range of lead that would be expected to have been brought onto the sites by property owners as LBP based on the age of the homes and the common use of LPB, particularly before the mid-century.

2) The percentage of lead in the soil relative to LBP is generally higher for older homes. This is consistent with the change in awareness of the risk of LBP over time and the resulting improvement in housekeeping and management of paint waste in the latter half of the 20th century. The older the home, the greater the likelihood of paint (and its associated lead) being relocated into the yard from loss during painting, scrapping, pealing and flaking, chalking, and cleaning of paint equipment (Figure 7-2).

3) The highest mass of lead in soils is associated with older homes and unrelated to distance from the former USMR facility. All properties, except one, with greater than 100 pounds of lead above the mid-range estimate of background in the top one foot of soil have residences that were constructed before 1920.

4) The soil lead mass generally decreases with newer residences, with one exception. The one property with lead in the soil greater than 100 pounds above background and anomalous with respect to the decreasing trend with newer homes is 54 Arthur Avenue (PPIN 5631). This property was constructed in 1953 and has one soil measurement location driving the average estimate. The locations of the samples for this property are shown on Figure 7-3. The one very high lead measurement location has concentrations of 10,700 ppm at 0-6 inches and 2,180 ppm at 6-12 inches. These samples were collected adjacent to a shed along a fence line. When these measurements are removed, the average yard concentrations are more in line with properties with homes constructed after 1950.

5) The variation in lead in soils is correlated with the age of homes and the relative amount of LBP usage, with no apparent correlation with spatial location relative to the former USMR facility.

SUMMARY OF POTENTIAL IMPACT FROM LEAD-BASED PAINT*

Median estimate of potential lead brought onto property in lead-based paint:	**1,063.4 pounds**
Total pounds of lead in top 1 ft. of soil:	**143.34 pounds**
Total pounds of lead in top 1 ft. of soil excluding background:	**117.5 pounds**
Potential amount of lead from lead-based paint in soils:	**11 %**
Potential amount of lead remaining on/in house:	**946 pounds**

*Example calculations from PPIN 5271

Figure 7-2. Pathways of LBP to Soils

Figure 7-3: PPIN 5631 Average Lead Concentrations

7.1.1.4 Physical Observations

NewFields personnel conducted two rounds of street-level property inspections within the proposed class area. The first round of property inspections covered 550 properties across the entire proposed class area and the second round focused on the 38 transect properties sampled by USMR. During both rounds of property inspections, any signs of peeling or chipping paint on a property were noted. Of the 550 properties inspected during the proposed class-area wide property inspection, 152 (28%), of the class-wide properties and 16 of the 38 (42%) USMR transect properties had visible signs of peeling paint. This number is likely an underestimate as the property inspections were conducted from the sidewalk or street, limiting the portions of the property that were visible. Examples of properties with peeling paint are shown in Figure 7-4.

Figure 7-4. Examples of Peeling Paint observed in Carteret

7.1.1.5 Analytical Confirmation of LBP as Parcel-specific Source

In instances where peeling paint or paint chips in the soil are not observed with the naked eye, laboratory analytical analysis can still determine if soils at a property have been impacted by LBP. For example, the scanning electron microscopy with energy dispersive spectrometry (SEM-EDS) conducted by Mr. Mattingly is capable of definitively identifying the presence of LBP based on the microscopic shape of the lead paint fragments and the presence of lead in these fragments. Similarly, even where paint fragments are degraded the SEM-EDS identification of barium and titanium co-located with lead are evidence of LBP impacts because these are common ingredients of paint that are identifiable with SEM-EDS.[97] Figure 20 from Mr. Mattingly's report, reproduced below as Figure 7-5, illustrates this point. The characteristic shape of the paint fragment is apparent in pictures C and D and the spectra indicating high lead, titanium and barium content is shown in pictures E and G.[98]

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[97] Mattingly, 2019. Pg. 42/64.
[98] Mattingly, 2019. Pg. 42/64.

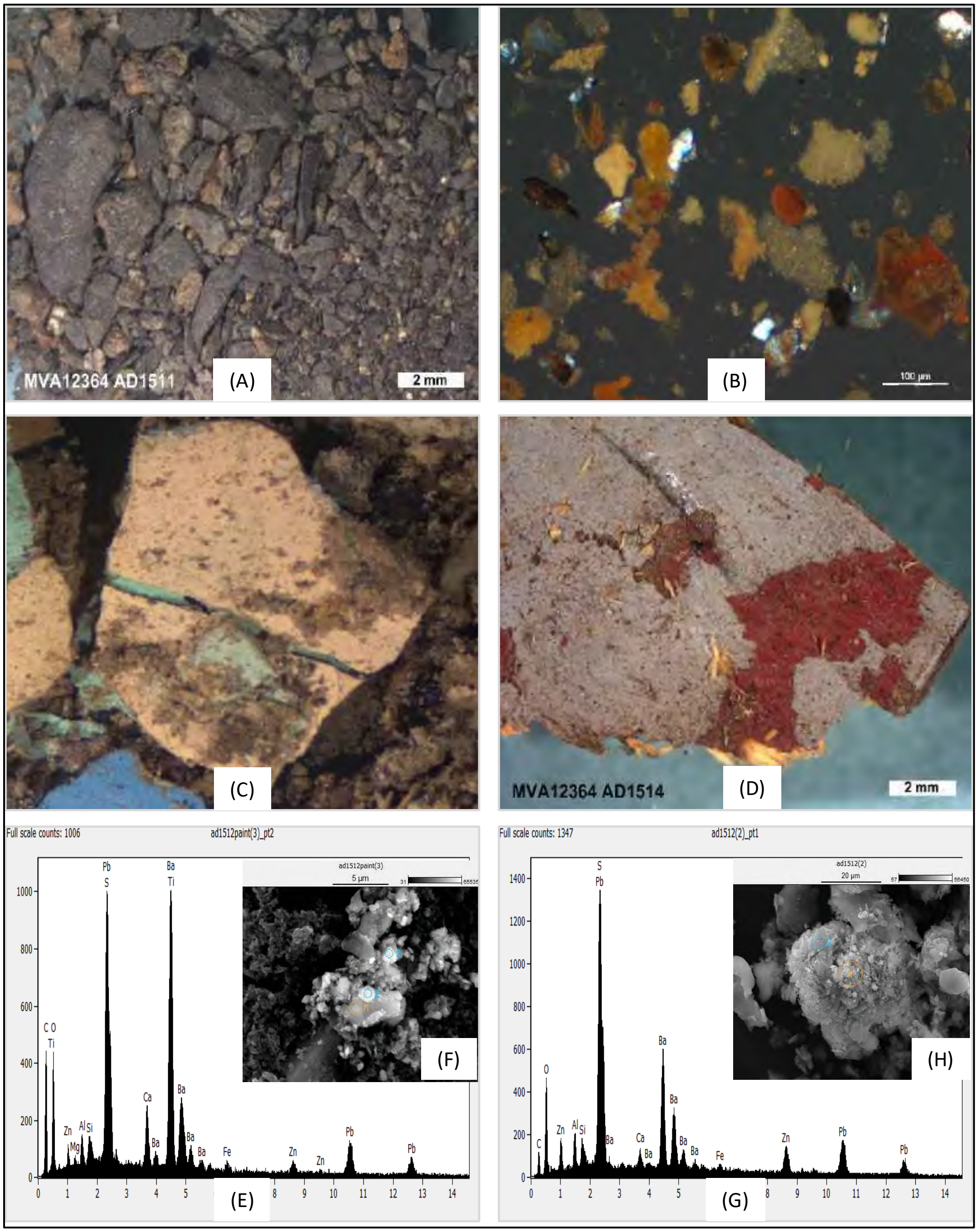


Figure 7-5. Microscopic analysis of LBP in soils (Figure 20 from Mattingly report)

As shown in Figure 30 of Mr. Mattingly's report and reproduced below as Figure 7-6, the SEM-EDS work identified LBP impacts in multiple soil samples taken from both within the AOC and the transects.[99]

[99] Mattingly, 2019. Pg. 62/64.

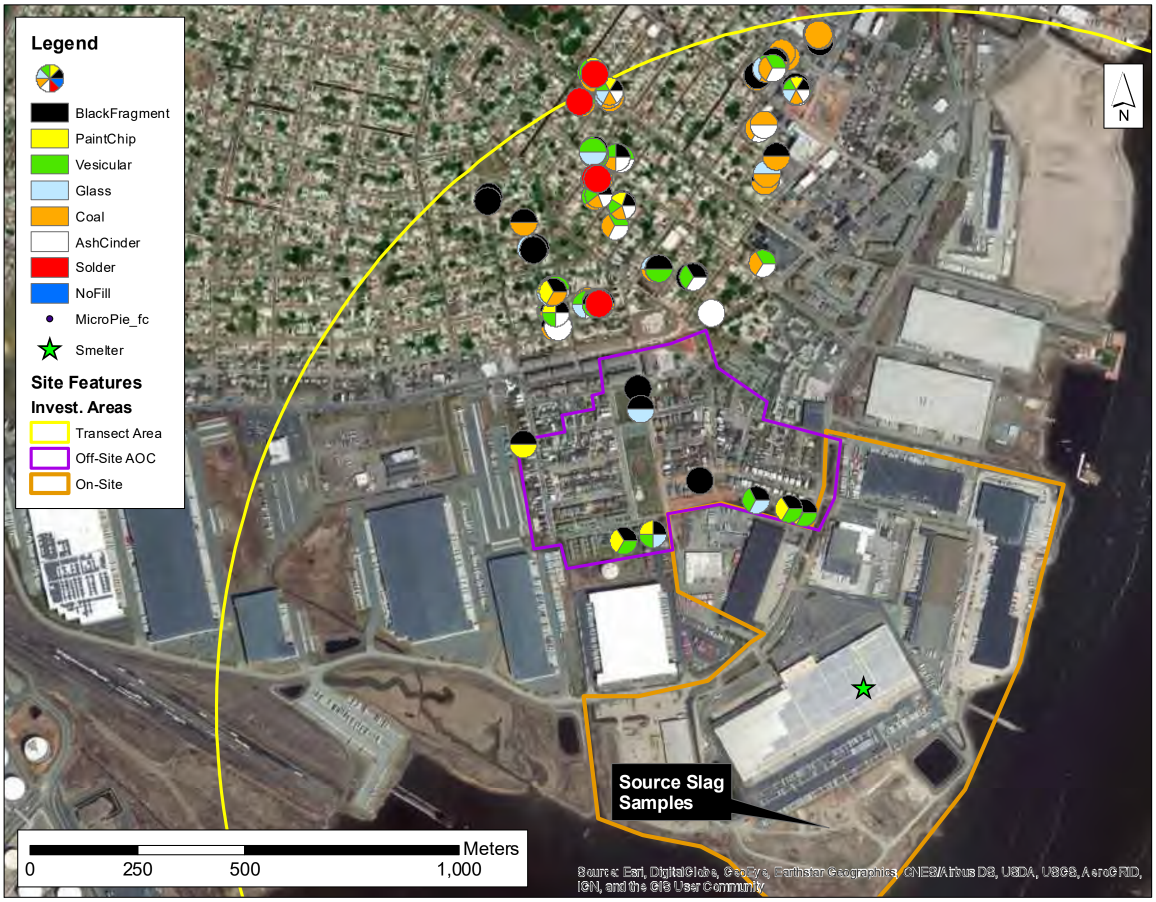


Figure 7-6. Variable Types of Fill Identified Throughout the Carteret Study Area (Figure 30 from Mattingly Report).

7.1.1.6 Visualization of Spatial and Temporal Lead Concentrations

The previous sections establish that LBP was capable of creating a significant loading of lead into the proposed class area and that the loading would be a function of the age and size of the homes, which would affect the volume of LBP brought onto properties by property owners for home upkeep. This section provides a visual analysis of soil lead relative to three variables that could have influenced the presence of soil lead on specific parcels in Carteret. These three variables are age of residence, size of residence, and location in the community. The analysis utilizes the lead sample results for all 77 residences sampled at two depths along three transects emanating from the former USMR facility (e.g. both USMR and Plaintiff transect samples) (see Figure 4-1).

The visual analysis is provided in Figures 7-7A and 7-7B (provided at the end of this section) with supporting information provided in Appendix A, Figures A-13 through A-23. The figures provide the information as described below.

Description of Symbology

The symbology provides information relevant to visualization for each of the 77 properties of the relationship between residence size, age, and lead concentration in the two sampled layers (0-6 inches and 6-12 inches), and average across the layers. This information is provided in a single symbol block.

Time of construction is also provided as an axis in Figure 7-7A. Both time of construction and distance from the former USMR facility are provided as axes in Figure 7-7B.

- The sizes of the symbols for each variable are scaled relative to the highest value for that variable across the 77 sampled residences. For example, the highest average lead concentration across the two layers is 1,152 ppm at 28 Lowell street (PPIN 6408). The average concentration at 145 Carteret Ave (PPIN 6716) is 283 ppm. The lead symbology for 145 Carteret is depicted at 25% of the size of the 28 Lowell Street symbol.
- To assist rapid visualization of characteristics, each variable is also color coded.
    - Average yard lead concentrations in any layer (0-6 in., 6-12 in., or 0-12 in.) below the midrange estimate of lead background (less than 139 ppm) are coded green. Average yard lead concentrations between the mid-range and high estimate for background (between 139 and 278 ppm) are coded yellow. Average yard lead concentrations greater than the highest estimate for lead background (278 ppm) are coded red.
    - The housing age color symbology indicates whether the house size is large, medium, or small based on the housing sizes for the 77 sampled properties. The basis for the division of the color coding is shown in Figure 7-7A. The group of the largest homes based on square footage (greater than 2,300 square feet) is coded red, the medium-sized homes (between 1,700 and 2,300 square feet) are coded yellow, and the smaller homes (less than 1,700 square feet) are coded green.
- The relative range of the average yard lead for the 0-12 inch layer, which represents the mass of lead in the yard, is indicated in the block containing the residence PPIN number and is coded green, yellow, or red in accordance with the criteria above.
- The years the residence was constructed before the banning of LBP for residential use in 1978 is provided on the symbol, as well as the PPIN number.

Figure 7-7A and 7-7B -Data Summary

These two figures provide a compilation of the yard lead characteristics, home size, date of construction, and distance from the former USMR facility. Figure 7-7A represents all the variables being investigated in this section. Figure 7-7B simplifies the information, showing the relative average soil lead concentration, whether the concentrations are low, medium, or high relative to background ranges, the date of home construction, and distance of the parcel from the former USMR smelter stack. Supporting figures showing additional detail regarding the location of the homes and the distribution along transects is provided in Appendix A.

7.1.1.7 Conclusions Regarding Lead Distribution in Carteret

The following conclusions are derived from Figures 7-7A and 7-7B (also Appendix A figures A-1 – A-12).

1) The age, and to a lesser degree the size of the home, is predictive regarding the relative concentration of lead within a yard.
    a. The highest yard lead concentrations are overwhelmingly associated with homes constructed before 1940.

   b. The mid-range of yard lead concentrations are overwhelmingly associated with homes constructed from the early 1940s to early 1950s.
   c. The lowest yard lead concentrations at or below regional background concentrations are overwhelmingly associated with homes constructed after the early 1950s.

2) The distance from the former USMR facility of a parcel is not predictive regarding the relative concentration of lead in the yard. Figure 7-7C highlights several clusters that demonstrate this characteristic.
   a. Elevated lead concentrations relative to background can be found at residences closer to the former USMR facility as well as farther away from the former USMR facility (cluster 1 and 2 on Figure 7-7C).
   b. Low lead concentrations relative to background can be found at residences close to the former USMR facility as well as farther away from the former USMR facility (cluster 3 and 4 on Figure 7-7C).
3) Figure 7-8 is a linear plot of the soil concentrations along the central transect with the average year of construction for the sampled properties also plotted. This figure reinforces the above conclusions. The figure shows that variations in lead concentrations observed in the USMR and plaintiff transect properties are driven by age of house and not distance from the former USMR facility. The increase in lead concentrations observed around 4,500 feet from the former USMR facility corresponds to an increase in housing age. As concentrations decrease between 4,000 feet and 6,000 feet from USMR, so does the housing age.

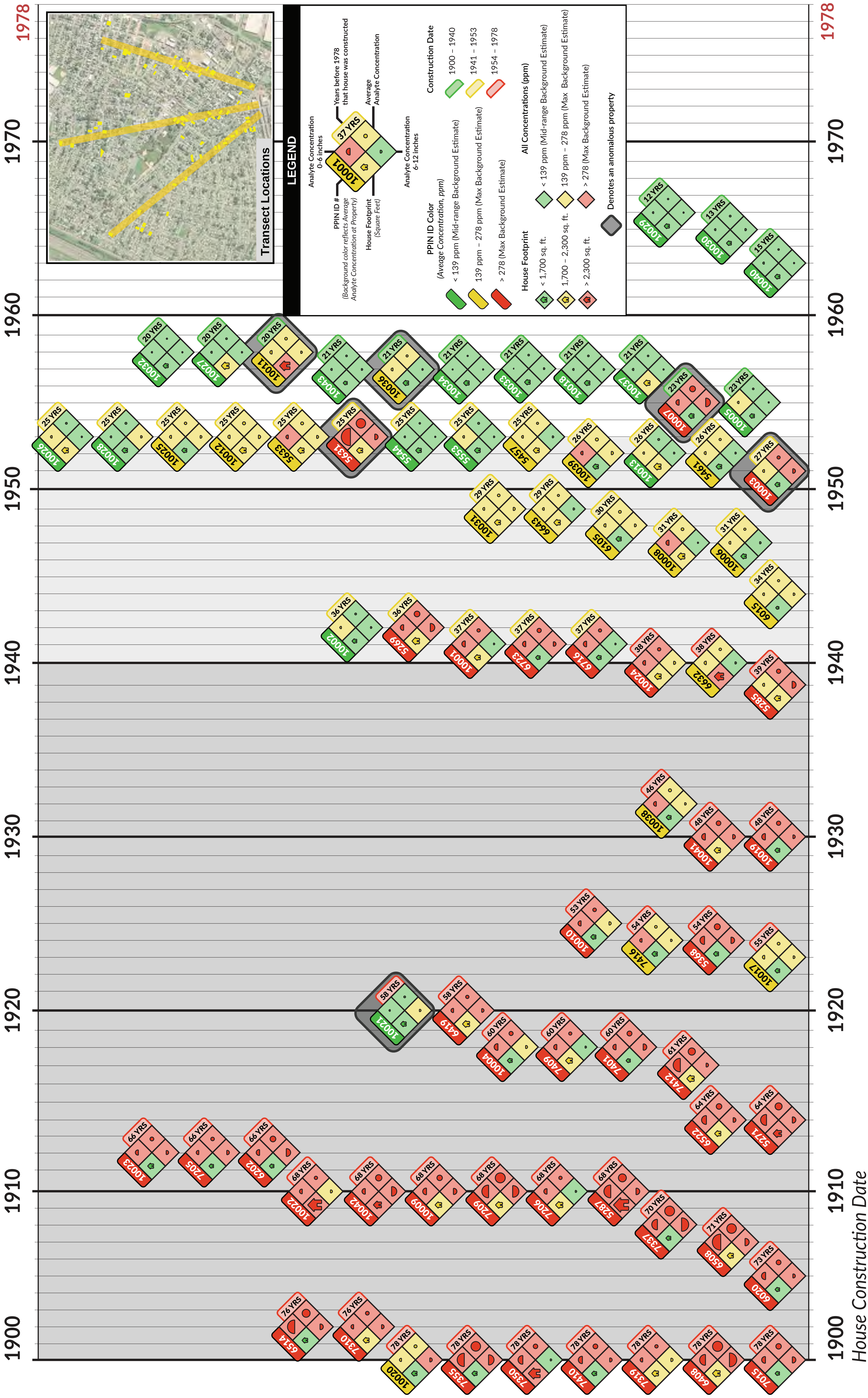
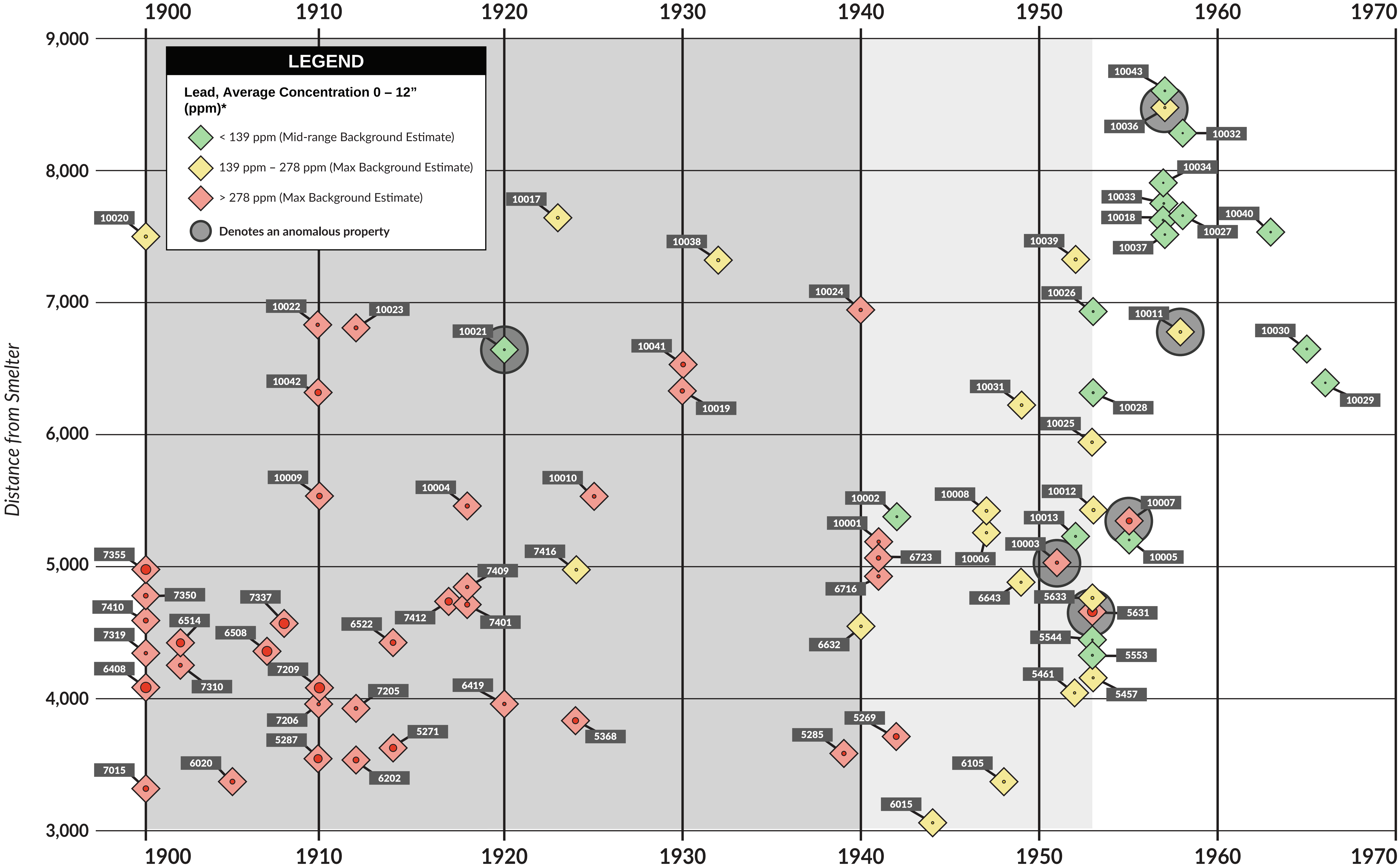


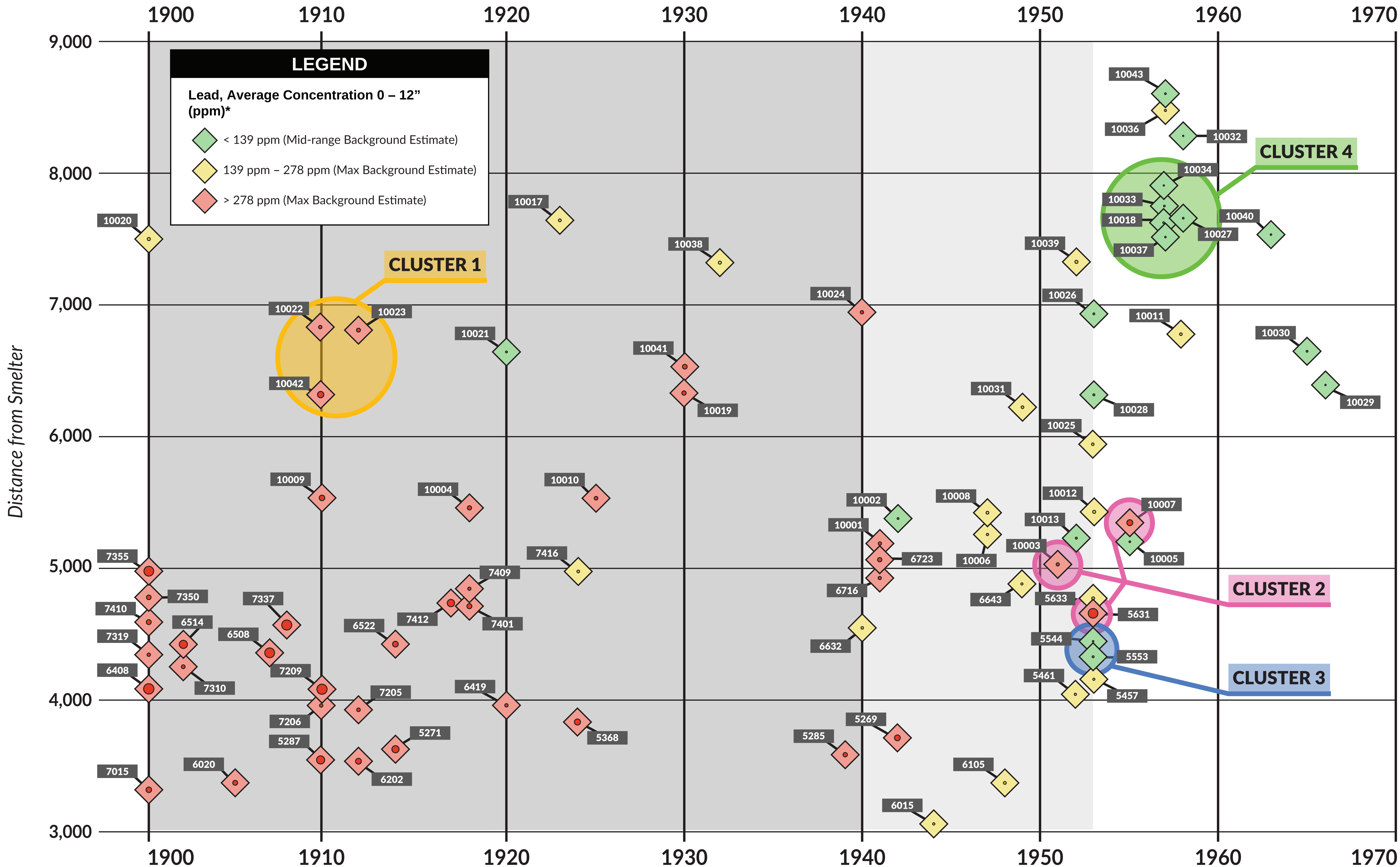
Figure 7-7A: All Transects Lead Concentration Time Series

Figure 7-7B: All Transects Lead Concentration Construction Date/Distance



*Dots are scaled relative to the maximum average yard concentration

Figure 7-7C: All Transects Lead Concentration Construction Date/Distance



*Dots are scaled relative to the maximum average yard concentration

House Construction Date

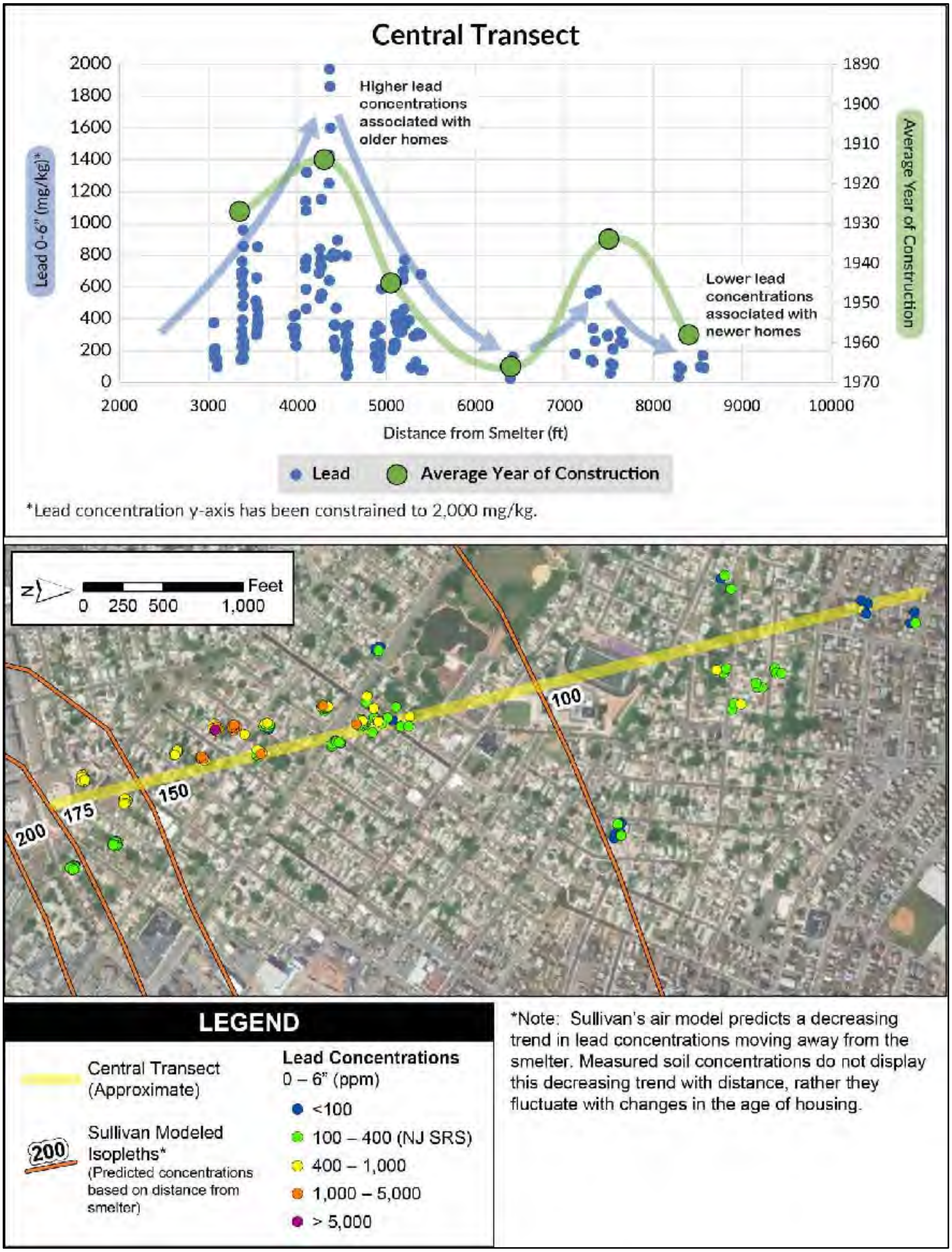


Figure 7-8 – Lead Concentrations and Average Construction Dates in Central Transect Parcels

Exceptions exist from the above trend. Each exception can be explained based on parcel specific conditions. The exceptions are highlighted on Figure 7-7A and 7-7B and discussed below. The parcel specific explanations demonstrate that the characteristics of lead within the Carteret community are parcel specific and can be explained by examination of the conditions unique to each parcel, independent of any relationship to the former USMR facility.

a. *PPIN 10021- 93-95 Sharot Street- older home with lower lead concentrations*
This parcel has a home originally constructed in 1920. The average soil concentration from four samples (2 depths in 2 locations) is 114 ppm, below the midrange estimate of lead background of 139 ppm (see Appendix A figure A-13). Two of the samples were collected in the front yard either adjacent to or in a vegetable bed (Figure 7-9). The other two samples were collected in the back yard with the deep sample having a much higher lead concentration. The presence of the vegetable bed increases the likelihood that mulch or topsoil has been brought onto the property and thus the chance that the low lead concentrations are the result of clean topsoil.

b. *PPIN 10003- 44 Cyprus Street- intermediate age home with high lead concentration*
This home constructed in 1951 is in the intermediate age range. While this home appears to be an exception based on Figures 7-7A and 7-7B, the average lead concentration of 283 ppm is only slightly above the maximum background lead concentration of 278 ppm used for this analysis.

c. *PPIN 5631 – 54 Arthur Avenue. – newer home with high lead concentration*
This home constructed in 1953 has two sample locations out of 10 (Figure 7-3) that are an order of magnitude higher than the other eight locations. These two locations are along a fence line on the edge of the property. The average lead concentration including these two locations is 992 ppm. Without these two locations the average lead concentration is 272 ppm. The difference in concentrations is indicative of a highly localized source that is not associated with air deposition.

d. *PPIN 10007- 60 Linden Street- newer home with high lead concentrations.*
This home constructed in 1955 has one sample location within a drainage swale between two residences (Figure 7-10). The average yard lead concentration with this location included is 625 ppm (see Appendix A figure A-14). Without the two samples from the location in the drainage swale, the average lead concentration is 214 ppm. Additionally, this sample is within the boundaries of an old road from the 1930s (Figure 7-11). The existence of the swale and the old road shows additional potential sources that likely contributed to the elevated lead concentrations observed that are unique to this particular property.

e. *PPIN 10011-149 Lowell Street- newer home with moderately high lead concentrations.*
This home constructed in 1958 has one sample location that is elevated over the others (Figure 7-12). The average lead concentration with the samples from this location is 214 ppm. Without this location, the average lead concentration is 132 ppm, which is below the midrange background value. These elevated levels are explainable from parcel specific conditions. The sample location is within the boundaries of a roadway that existed in the 1930s (Figure 7-13). In addition, it is adjacent to Noe's Creek, which was

filled in over time.[100] Based on the 1954 aerial (Figure 7-14), this area was apparently filled in by the 1950s. Noe's Creek is discussed in more detail in Section 7.2. and in the expert report by Mr. A.J. Gravel.

f. *PPIN 10036-29 Chestnut Street- newer home with moderately high lead concentrations.* Although the samples are attached to a home constructed in 1957, examination of the historical aerials demonstrate that it is a location associated with a much older building. Figure 7-15 is a 1930 aerial of the location of the samples. The samples were collected in a location that prior to 1957 was in the backyard of a building. Although it cannot be determined what specific activities were conducted in this area, there was clearly extensive anthropogenic activity as the land surface appears bare. It also has the appearance that this area was a transit route leading from the building to farmed areas to the south.

Source: Google Street View

Figure 7-9. Garden Bed at 93-95 Sharot Street

[100] Gravel, 2019, pg. 33-34/77.

Source: Google Street View

Figure 7-10. Drainage Swale at 60 Linden Street

Figure 7-11. PPIN 10007 Lead Concentrations and 1930 Aerial

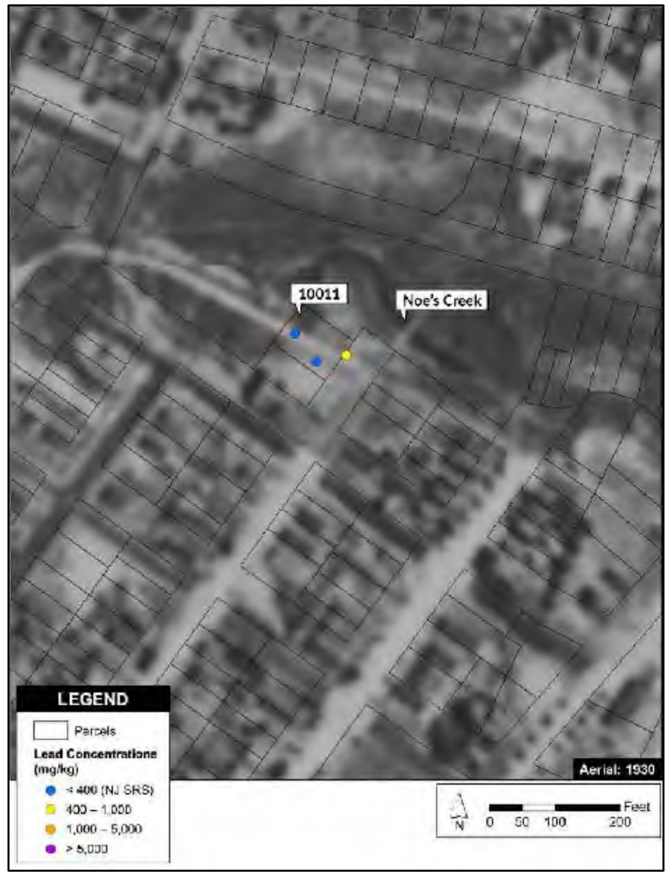
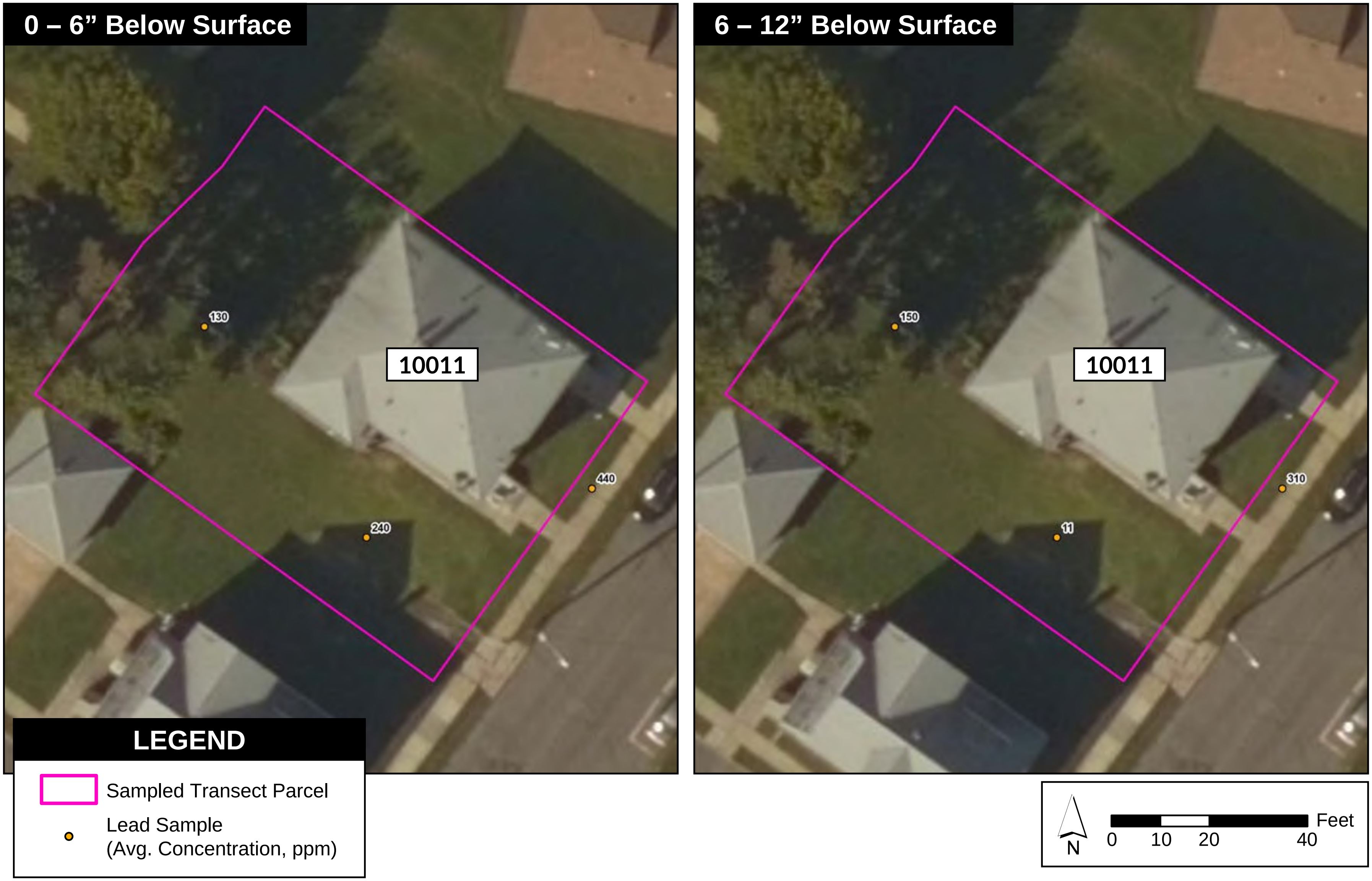


Figure 7-13. PPIN 10011 Lead Concentrations and 1930 Aerial

Figure 7-12: PPIN 10011 Sample Locations



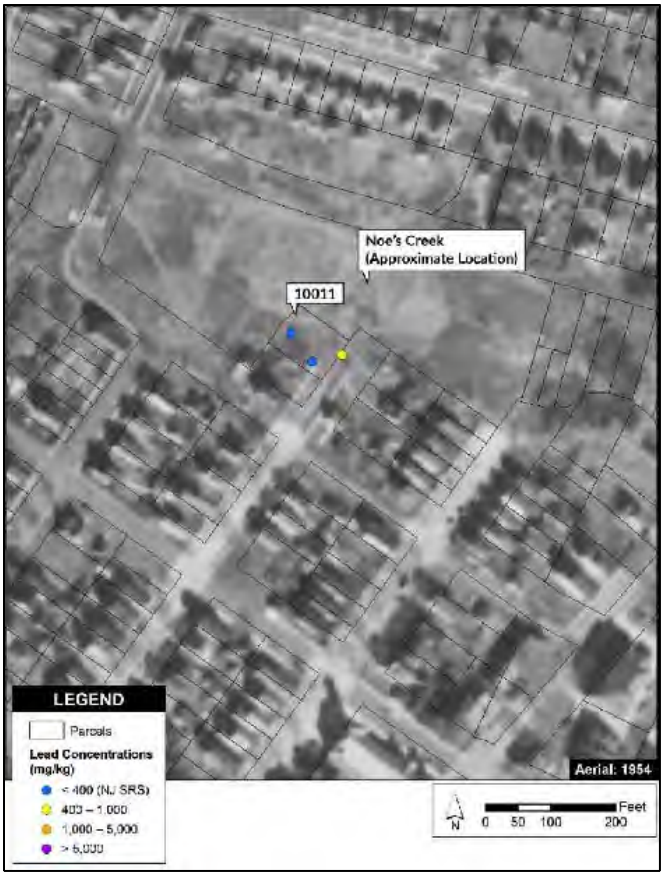


Figure 7-14. PPIN 10011 Lead Concentrations and 1954 Aerial

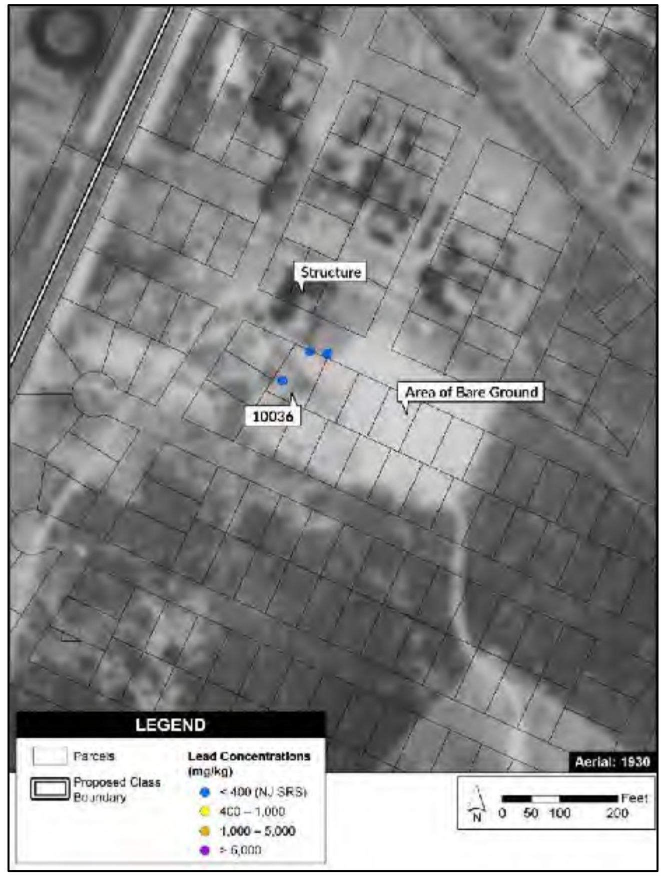


Figure 7-15. PPIN 10036 Lead Concentrations and 1930 Aerial

Figures 7-16A and 7-16B show the decrease in average lead concentrations for the 77 USMR and plaintiff transect properties grouped by decade of house construction. Figure 7-16A incorporates all properties while Figure 7-16B excludes the six properties discussed above (3a through 3f). Both figures demonstrate that the average lead concentration decreases as home age decreases. Additional discussion of the confounding factors from fill and localized commercial activity is provided in Sections 7-2 and 7-3, respectively.

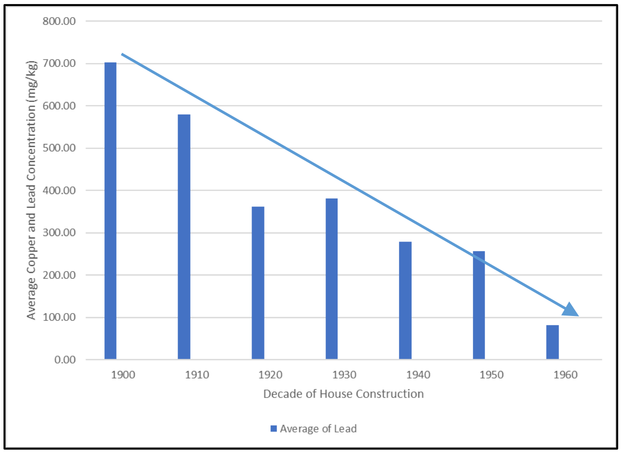


Figure 7-16A – Average Lead by Decade with USMR + plaintiff transect properties included

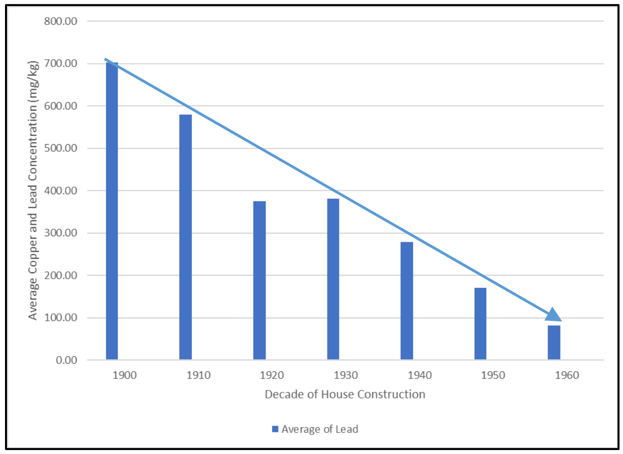


Figure 7-16B – Average Lead by Decade of House Construction excluding 6 exception properties

7.1.2 Opinion 3-1B – Copper and Arsenic Parcel-specific Characteristics

Outside of the immediate vicinity of the former USMR facility, the distribution of copper and arsenic is highly variable with no correlation to distance from the former USMR facility. The variability is similar to that of lead, indicating that these metals are the consequence of parcel specific activities. These activities included pesticide, herbicide, fungicide, and wood preservative uses both on individual parcels and more generally in the community.

7.1.2.1 Treated Wood

Copper-chromated arsenic (CCA) was invented in 1933 and has been used in timber treatment since the mid-1930s. In 2003, U.S. manufacturers began a voluntary phase-out of CCA for certain residential uses but it is still used for treating utility poles, building lumber, wood foundations, and industrial uses.[101] Approximately 70% of homes in the United States have decks or porches containing pressure-treated wood.[102]

Since the phase out of CCA in 2003, CCA has been replaced by other preservatives that still contain copper, including ammoniacal copper quaternary and copper azole.[103] Stook et al (2005) found that more copper leaches out of the arsenic-free alternatives than CCA.[104]

In addition to CCA, copper sheeting is often used in residential buildings on roofs, gutters, facades, and as decorative ornamentation. Ray (2009) estimated that the annual average runoff from a copper roof in New Jersey was 3.14 g/m2.

Treated wood has been observed throughout the proposed class area. During the inspection of the two named plaintiff properties (3-A and 3-B Salem Ave.) in May 2018, X-ray fluorescence (XRF) samples were collected throughout both properties. Bulk materials (soil, wood, and paint) were also collected from both properties and sent to a laboratory for analysis.[105]Both the XRF and bulk materials confirmed the

[101] ATSDR, 2007. Pg. 22/559.
[102] National Library of Medicine HSDB Listing for CCA. Pg. 1/35.
[103] Washington Department of Ecology, 2006. Pg. 1/3.
[104] Stook et al., 2005. Pg. 1/1.
[105] Litherland, 2018. Pg. 1/41.

presence of treated wood at both properties. An XRF sample of the deck post at 3-A had a result of 6,929 ppm for copper. Arsenic, Copper, and Lead were detected in XRF samples from landscape timbers and fencing at 3-B.[106] Bulk wood samples from both properties confirmed the XRF results. A sample of wood from the deck post at 3-A had a copper concentration of 4,840 ppm and a sample of wooden lattice had an arsenic concentration of 1,040 ppm and a copper concentration of 626 ppm. At 3-B, a fence post in the backyard had an arsenic concentration of 3,240 ppm and copper concentration of 2,040 ppm, while a landscape timber near a flower bed had an arsenic concentration of 1,960 and copper concentration of 626 ppm.

Utility poles treated with CCA are also located throughout the proposed class area. During the property inspection process, NewFields personnel also identified and located utility poles treated with CCA within the proposed class area (Figure 7-17). A total of 225 CCA-treated poles were identified within the proposed class area. Poles were identified based on markings placed on the poles by the manufacturer. The SK code on the pole is the preservative code for CCA that identify CCA as the preservative (Figure 7-18).

[106] Litherland, 2018. Pg. 6/41.

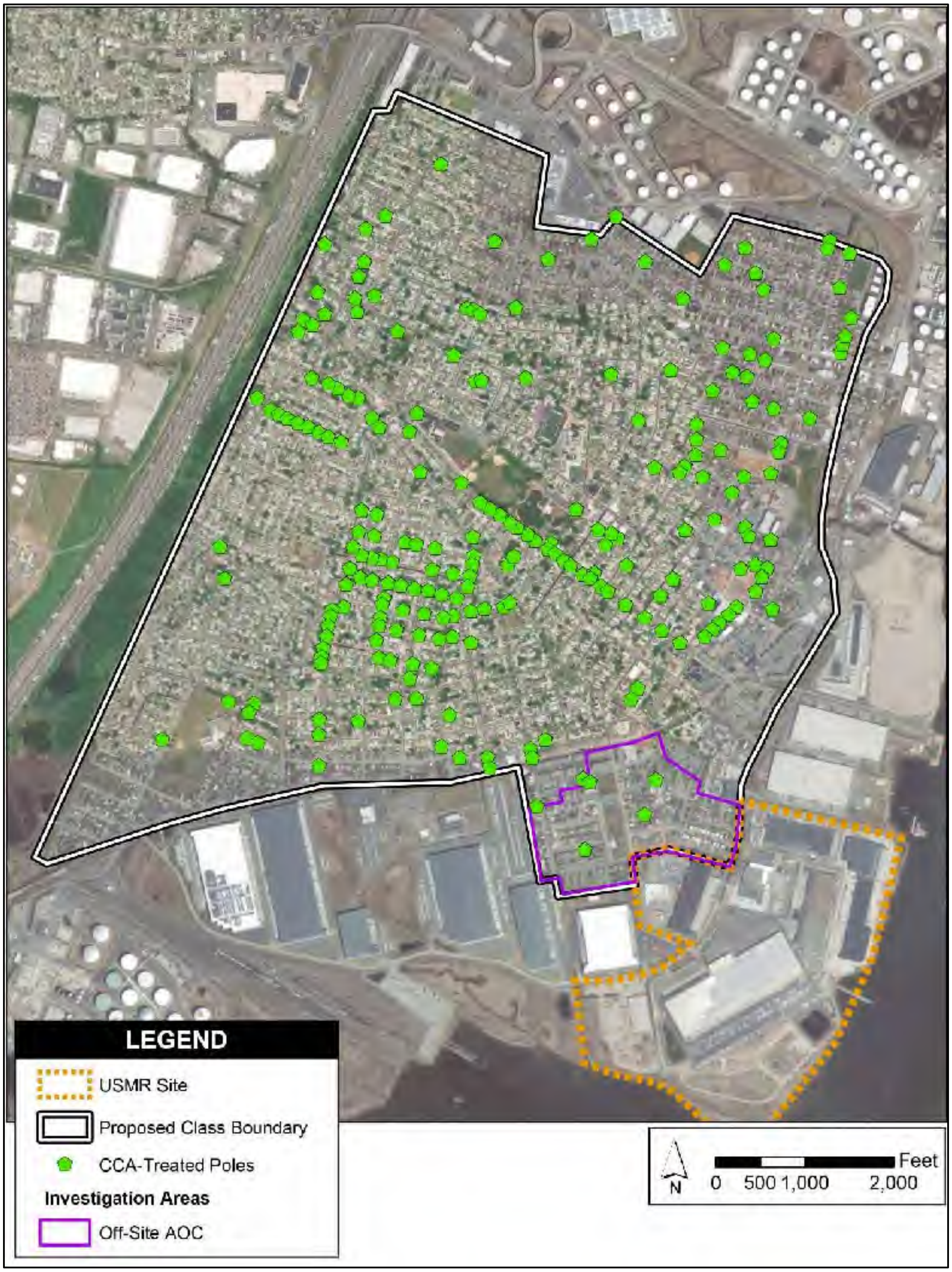


Figure 7-17 – Utility Poles Treated with CCA

Figure 7-18. Photo of markings on CCA-treated utility pole at 29 Ash Street.

NewFields personnel sampled six CCA-treated utility poles and one creosote treated pole with an XRF. Two to three scans were collected from each pole and the results were averaged. The XRF results are summarized below in Table 7-3. Arsenic concentrations in the CCA-treated poles range from 1,806 ppm to 10,176 ppm and copper concentrations range from 1,365 ppm to 7,497 ppm. In comparison, arsenic was not detected in the pole treated with creosote and copper was detected at 123 ppm, an order of magnitude lower than the CCA poles.

Table 7-3. XRF results from utility poles in Carteret.

Sample ID	Treatment	Units	As	Cr	Mn	Cu	Zn	Ti	Hg	Pb
Utility Pole A	CCA	mg/kg	1806	4747	116	1364.5	135	5121	0	0
Utility Pole B	CCA	mg/kg	5464.5	7167.5	199	5052	652	2053.5	72	24
Utility Pole C	CCA	mg/kg	6089.5	7293	231.5	4296	0	0	67	0
Utility Pole E	CCA	mg/kg	10176	13336	313.7	7497	165	0	102	0
Utility Pole F	CCA	mg/kg	5358.5	6036	158.5	4048	84	2891.5	94	0
Utility Pole G	CCA	mg/kg	7497.7	14881	197.5	3840.7	0	0	77.3	0
Utility Pole D	Creosote	mg/kg	0	0	34	122.7	69.3	252	0	65

7.1.2.2 Gardens

Many of the metal-based pesticides used in agriculture were also available for household use. Residential use of arsenical pesticides has been known to cause widespread arsenic contamination in residential areas. In the case of a former lead smelter site near Denver, investigators found widespread metal contamination, as high as 1,000 ppm, attributable to the common use of a lead arsenate-based crabgrass killer common in the 1950s and 1960s.[107]

Newspaper garden columns in the area, many written by agricultural extension service agents, make many mentions of arsenical pesticides for the control of pests in home gardens and lawns. In 1926, a coastal New Jersey newspaper was advising homeowners to use lead arsenate not only to control caterpillars in their gardens, but on their dogs as flea control.[108] In the wake of a serious Japanese beetle infestation in the 1930s, the state Department of Agriculture advised homeowners to apply lead arsenate to their lawns if they found beetle grubs.[109] In 1936, the New Jersey Agricultural Extension Service was advising homeowners to protect their shade and forest trees from canker worms by applying lead arsenate.[110] Recommendations for homeowners to use lead arsenate on beetles and canker worms continued up until 1960[111], although at that point homeowners were told they could also use newer pesticides such as DDT and malathion.

In 1935, a garden column written by a representative of the extension service recommended that residents spray everything in their gardens with the Bordeaux mixture, a copper-based fungicide.[112] The agricultural extension service also recommended that homeowners use copper sprays and dusts to fight fungus on flowers.[113] In 1960, the Asbury Park Press was encouraging homeowners to use copper sprays on trees and shrubs to control fungus.[114] Documentation confirming the historical use of copper and

[107] Folkes 2001; Folkes 2010
[108] Asbury Park Press, 1926. Pg. 1/1.
[109] Camden Courier Post, 1931. Pg 1/1.
[110] Central Jersey Home News, 1936. Pg. 1/1.
[111] Asbury Park Press, 1960. Pg. 1/1.
[112] Central Jersey Home News, 1935. Pg. 1/1.
[113] Central Jersey Home News, 1945. Pg. 1/1.
[114] Asbury Park Press, 1960b. Pg. 1/1.

arsenic containing pesticides at residential properties is also contained in the expert report of Mr. A.J. Gravel.

Industrial concerns also used significant amounts of metals-based herbicides. Sodium arsenite was used to control weeds on railroad right of ways and on industrial sites.[115] Ash and Matsumoto (2010), in a survey of railroad corridors for elevated lead and arsenic, found that in five of the eight sites they surveyed, the land along the corridor exceeded local background concentrations of arsenic by a factor of 20 or more. The elevated concentrations were limited to the top two feet of soil, indicating that surface applications of pesticides were the most likely culprit.[116]

7.1.2.3 Pre-residential Agricultural Activities

As discussed in Section 8.0, extensive agriculture existed in the Carteret community prior to 1900. These agricultural applications would have been over larger areas likely spanning dozens of acres and would have produced a base loading in the community over areas including multiple parcels that is independent of current land use divisions.

7.1.2.4 Distribution of Copper and Arsenic Loading in the Carteret Area

The previous sections establish that there were multiple sources of copper and arsenic loading into the proposed class area. Loadings from residential applications would produce a more parcel-specific variability. This variability would be expected to more associated with the age and size of the homes, similar to the pattern observed with lead associated with LBP.

This section provides a visual analysis of copper and arsenic relative to the same three variables assessed for soil lead. These three variables are age of residence, size of residence, and location in the community. The analysis utilizes the sample results for all 77 residences sampled at two depths along three transects emanating from the former USMR facility (see Figure 4-1).

The visual analysis is provided in Figures 7-19, 7-20, and 7-21. The figures provide the information as described below.

Description of Symbology

The symbology provides information relevant to visualization for each of the 77 properties and the relationship between residence size and age, copper and arsenic concentrations in the two sampled layers (0-6 inches and 6-12 inches), average concentration across the depth layers, and distance from the former USMR smelter stack. This information is provided in a single symbol block.

- The sizes of the symbols for each variable are scaled relative to the highest average value on a property for that variable across the 77 sampled residences. The highest average copper concentration across the two layers is 1,124 ppm at 180 Pershing Avenue (PPIN 7337). The highest average arsenic concentration is at the same property and is 150 ppm (see Appendix A figure A-15).
- To assist rapid visualization of characteristics, each variable is also color coded.

[115] ATSDR, 2007. Pg. 331/559.
[116] Ash and Matsumoto, 2010. Pg. 4/12.

- Average yard copper concentrations in any layer (0-6 in., 6-12 in., or 0-12 in.) below the midrange estimate of copper background (less than 162 ppm) are coded green. Average yard copper concentrations between the mid-range and high estimate for background (between 162 and 324 ppm) are coded yellow. Average yard copper concentrations greater than the highest estimate (324 ppm) for copper background are coded red.
- Average yard arsenic concentrations in any layer (0-6 in., 6-12 in., or 0-12 in.) below the midrange estimate of arsenic background (less than 13.5 ppm) are coded green. Average yard arsenic concentrations between the mid-range and high estimate for background (between 13.5 - 26.9 ppm) are coded yellow. Average yard arsenic concentrations greater than the highest estimate (greater than 26.9 ppm) for arsenic background are coded red.
- The housing age color symbology indicates whether the house size is large, medium, or small based on the housing sizes for the 77 sampled properties. The bases for the division of the color coding is shown in Figure 7-19A. The group of the largest homes based on square footage (greater than 2,300 square feet) is coded red, the medium sized homes (between 1,700 and 2,300 square feet) are coded yellow, and the smaller homes (less than 1,700 square feet) are coded green.

- The relative range of the average yard lead for the 0-12 inch layer, which represents the mass of lead in the yard, is indicated in the block containing the residence PPIN number. The color coding is in accordance with the criteria above.
- The year of construction of the residence is provided on the symbol, as well as the PPIN number.

Figure 7-19A and 7-19B - Data Summary for Copper

These two figures (provided at the end of this section) provide a compilation of the yard copper concentrations, home size, year of construction, and distance from the former USMR facility. Figure 7-19A represents all the variables being investigated in this section. Figure 7-19B simplifies the information, showing the relative average copper concentration, whether the concentrations are low, medium, or high relative to background ranges, the year of home construction, and the distance of the parcel from the former USMR smelter stack.

Figure 7-20A and 7-20B - Data Summary for Arsenic

These two figures (provided at the end of this section) provide a compilation of the yard arsenic concentrations, home size, year of construction, and distance from the former USMR facility. Figure 7-20A represents all the variables being investigated in this section. Figure 7-20B simplifies the information, showing the relative average arsenic concentration, whether the concentrations are low, medium or high relative to background ranges, the date of home construction and distance of the parcel from the USMR smelter stack.

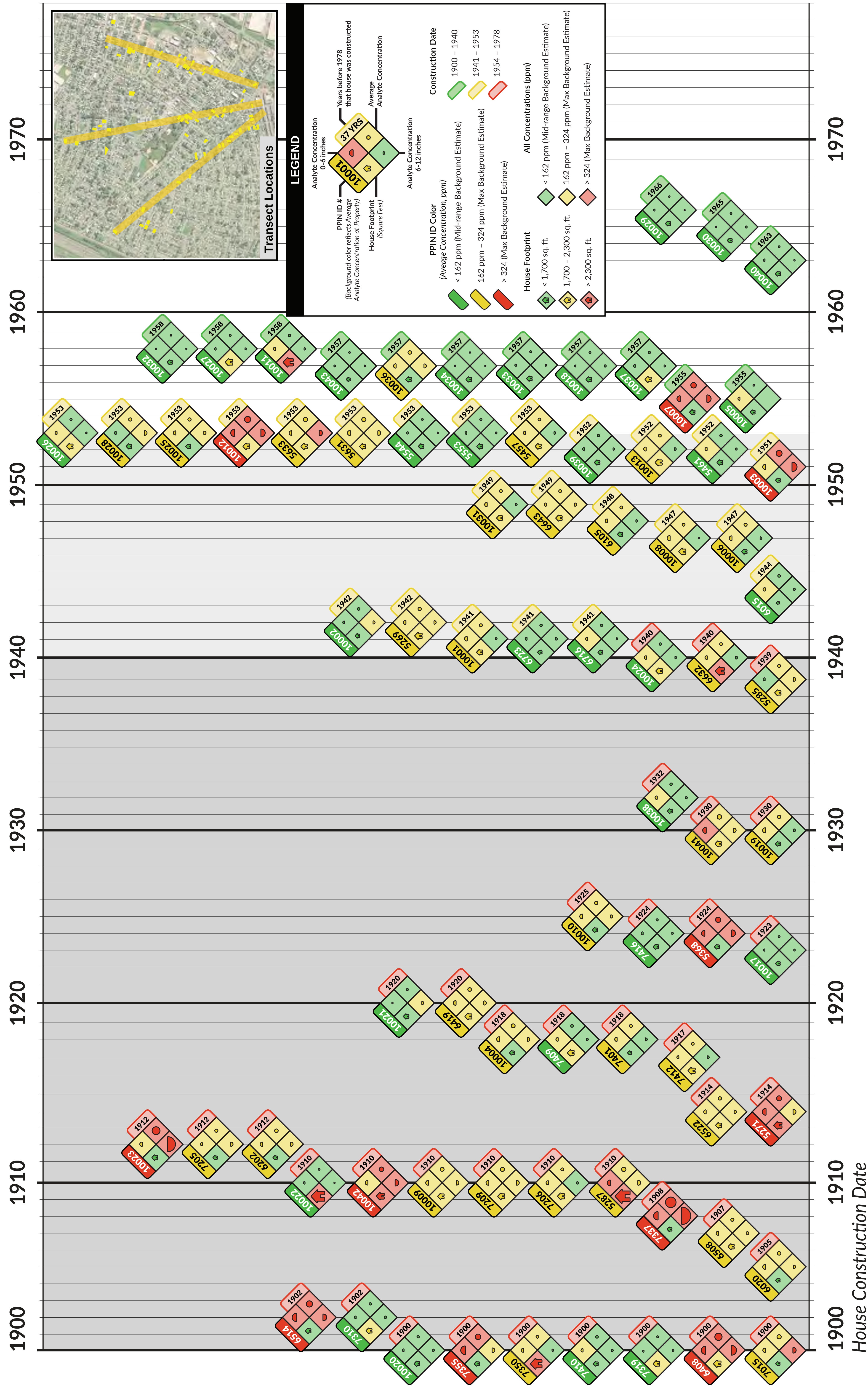
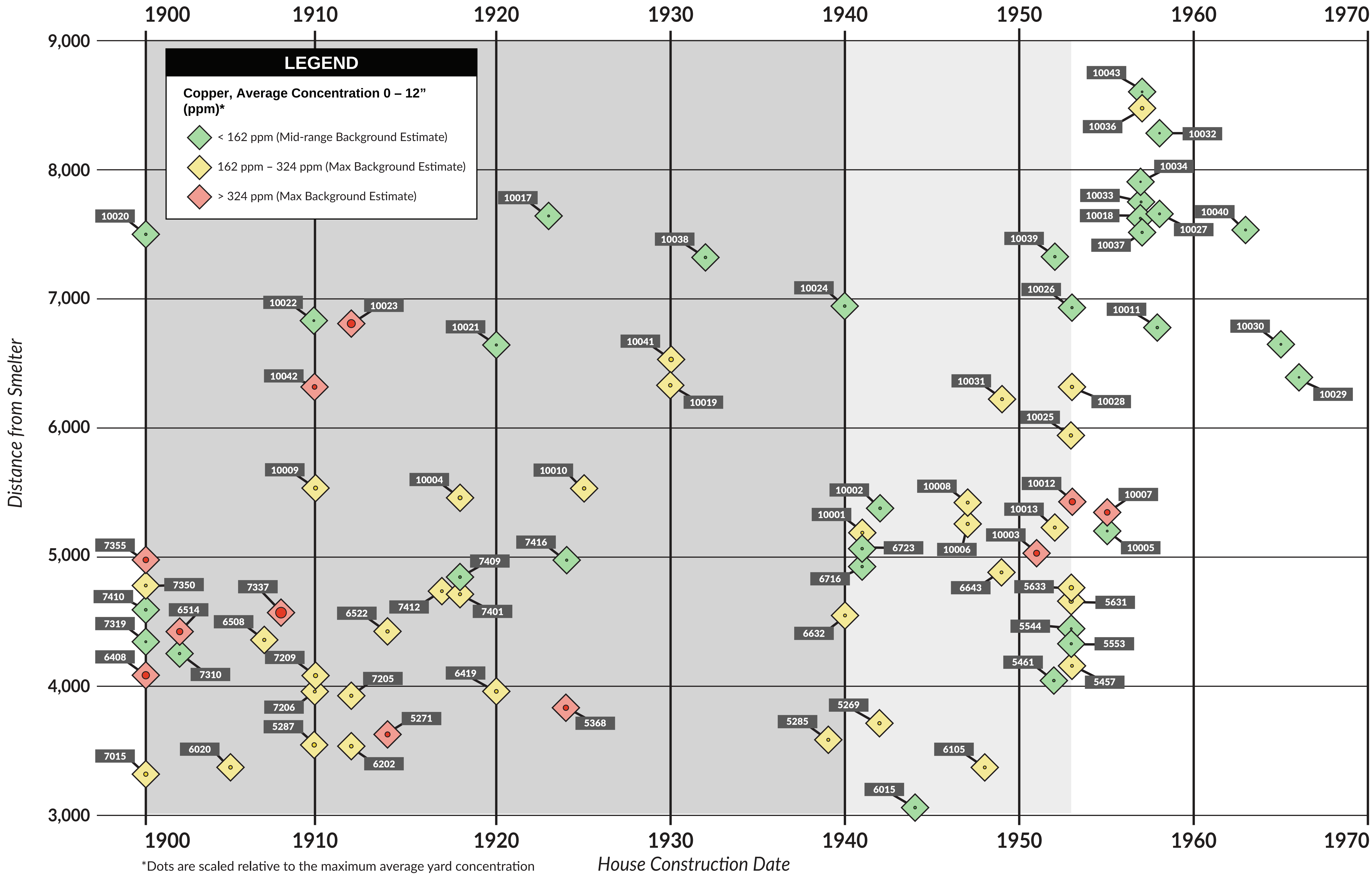


Figure 7-19A: All Transects Copper Concentration Time Series

Figure 7-19B: All Transects Copper Concentration Construction Date/Distance



*Dots are scaled relative to the maximum average yard concentration

Figure 7-20A: All Transects Arsenic Concentration Time Series

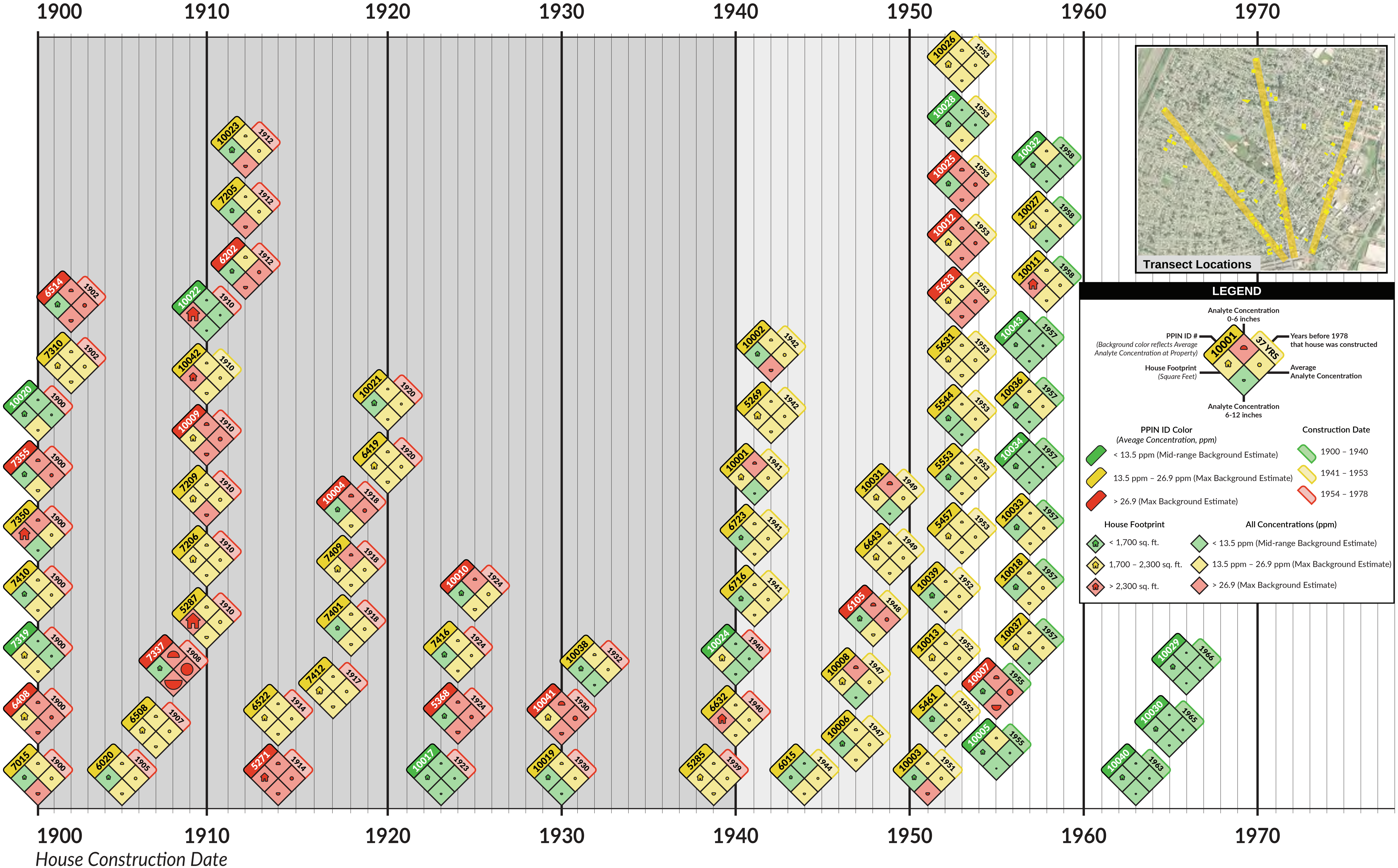
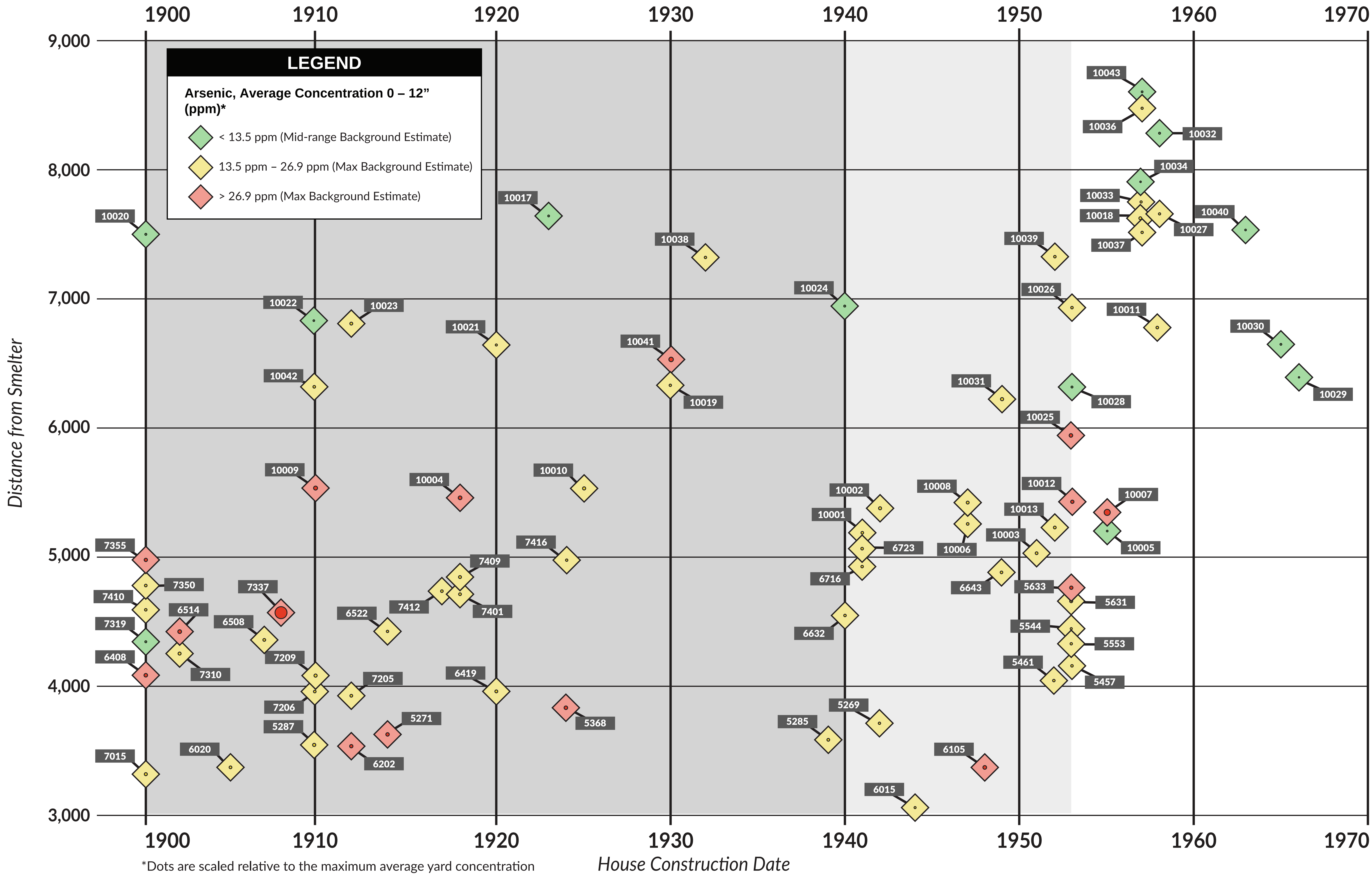


Figure 7-20B: All Transects Arsenic Concentration Construction Date/Distance



*Dots are scaled relative to the maximum average yard concentration

7.1.2.5 Conclusions Regarding Copper and Arsenic

The following conclusions are derived from Figures 7-19 A/B and 7-20 A/B.

Copper Concentration Patterns

1) Copper is not as strongly correlated to the age of residence (as compared to lead). However, there are patterns that demonstrate the presence of copper is associated with localized past land use activities.
    a. Average soil concentrations of copper are encountered most frequently above the background maximum on parcels with residences constructed before 1940.
    b. For parcels with residences constructed between 1940 and 1953, average soil concentrations of copper are rarely encountered above the background maximum, but average copper concentrations are frequently between the midrange and background maximum for copper.
    c. With only two exceptions, all of the parcels with residences constructed after 1953 have average copper concentrations below the midrange estimate of background.
2) The distance from the former USMR facility of a parcel is not predictive regarding the relative concentration of copper in the yard.
    g. High copper concentrations relative to background can be found at residences closer to the former USMR facility as well as farther away from the former facility.
    h. Low copper concentrations relative to background can be found at residences close to the former USMR facility as well as farther away from the former facility.
3) Figures 7-21A and 7-21B show the decrease in average copper and lead concentrations for the 77 USMR and plaintiff transect properties grouped by decade of house construction. Figure 7-21A incorporates all properties while Figure 7-21B excludes the six properties identified as exceptions in the lead discussion (Section 7.1.1.7 items 3a through 3f). Both figures demonstrate that the average copper concentration decreases as home age decreases, although the magnitude of the decrease is less for copper than that of lead. This is expected as copper does not have as distinct of a parcel-specific source as lead does with LBP.

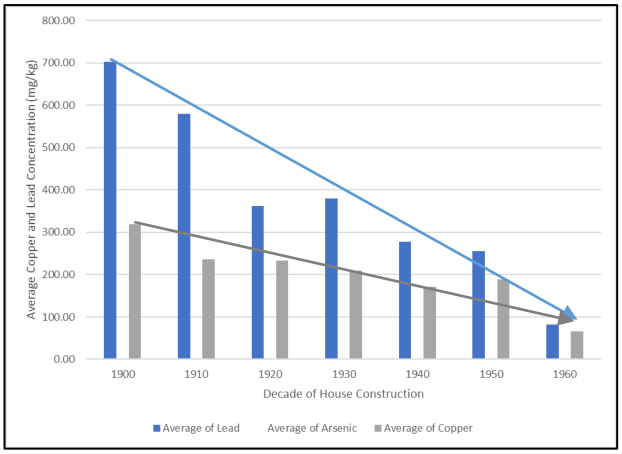


Figure 7-21A – Average Lead and Copper by Decade with all USMR + plaintiff transect properties included

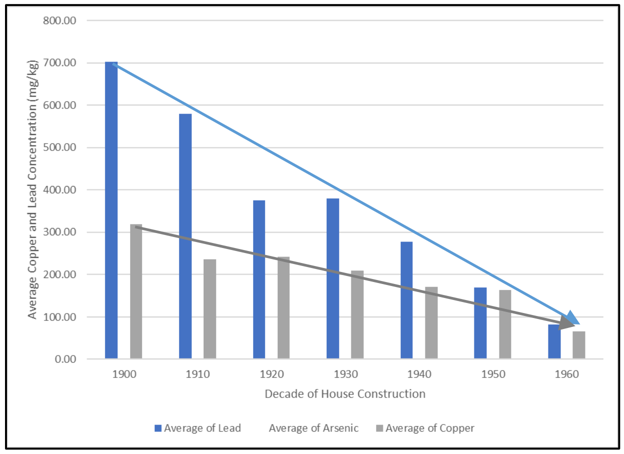


Figure 7-21B – Average Lead and Copper by Decade of House Construction excluding 6 exception properties

Arsenic Concentration Patterns

1) Arsenic is the most widespread of the three metals at average yard concentrations above the midrange background estimate. However, there are patterns that demonstrate the presence of arsenic is associated with localized past land use activities.
    a. Average soil concentrations of arsenic are encountered most frequently *above* the highest or midrange background estimate on parcels with residences constructed before 1940.
    b. The highest frequency of average arsenic concentrations *below* the midrange background estimate occurs on parcels with properties constructed after 1953.
2) The distance from the former USMR facility of a parcel is not predictive regarding the relative concentration of arsenic in the yard.
    a. High arsenic concentrations relative to background can be found at residences closer to the former USMR facility as well as farther away from the former facility.
    b. Low arsenic concentrations relative to background can be found at residences close to the former USMR facility as well as farther away from the former facility.

Figures 7-22A and 7-22B demonstrate that the patterns of metals detections on parcels follow what would be expected based on the use characteristics of these metals. The two figures show the decrease in average arsenic, copper, and lead concentrations for the 77 USMR and plaintiff transect properties grouped by decade of house construction. Figure 7-22A incorporates all properties while figure 7-22B excludes the six properties discussed above (Section 7.1.1.7 3a through 3f).

Both figures demonstrate that the average parcel concentrations for all three metals decrease as home age decreases. Lead, due to the dominance of LBP, is the most highly correlated with home age and demonstrates the most significant rate of decrease as year of construction increases. Copper also decreases as home age decreases. This is a function of less opportunity for the property-specific use of CCA as well as copper-based fertilizers and pesticides. Arsenic also decreases with home age but is the

least pronounced among the three metals. The arsenic pattern more closely resembles the copper pattern. This is expected as copper and arsenic likely had similar, agricultural-based sources.

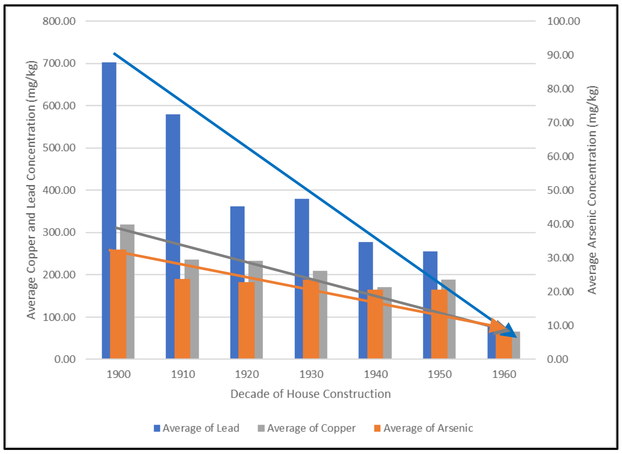


Figure 7-22A. Average Metals by Decade with all transect USMR + plaintiff properties included

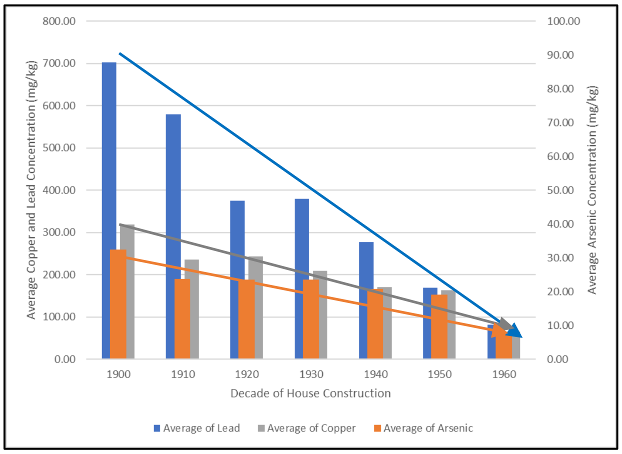


Figure 7-22B. Average Metals by Decade of House Construction excluding 6 exception properties

7.2 Opinion 3-2: Widespread Use of Fill Material

The use of fill materials was widespread throughout the Carteret area and there are multiple industrial sources of these fill materials. Non-native fill materials like those observed at properties in Carteret are known to be sources of arsenic, copper, and lead.

7.2.1 Overview

Due to the low-lying nature of the Carteret area, fill materials have been used throughout the proposed class area. Historical maps of the Carteret area show much of the current Carteret area was marshland and crisscrossed with streams. A 1781 map of Middlesex County shows several streams cutting across a large portion of the proposed class area (Figure 7-23).[117] An 1850 map of the County also shows several streams across the proposed class area as well as large swaths of Salt Meadows (Figure 7-24).[118] These features are no longer present, indicating that land leveling with fill and piping of stormwater has been widespread.

Figure 7-23. 1781 map of Middlesex County

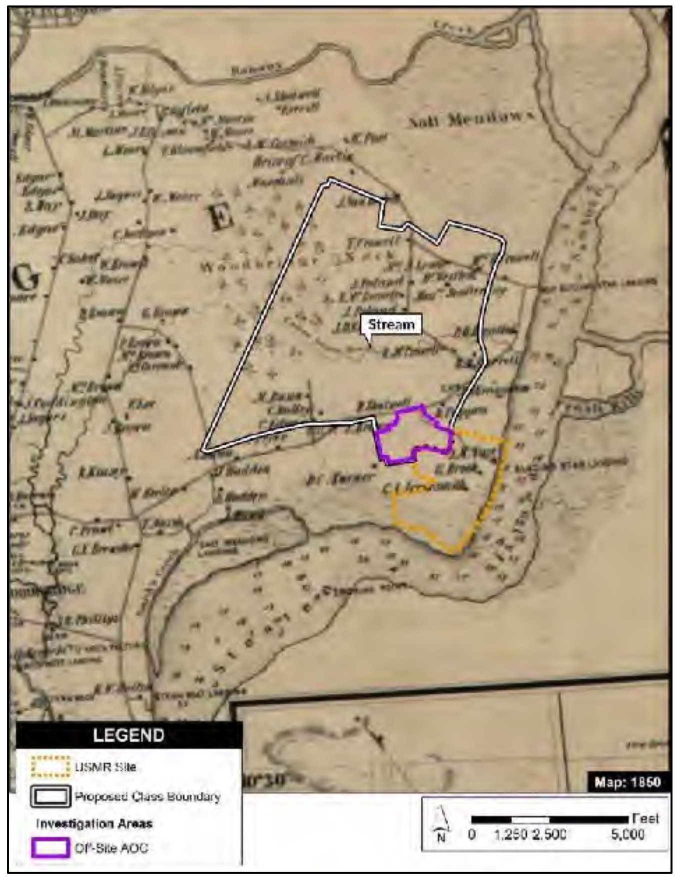


Figure 7-24. 1850 map of Middlesex County

As a result of the low-lying nature of the Carteret area, fill with good compaction and drainage properties was needed as development expanded across the proposed class area. New Jersey DEP has mapped areas of historic fill, where fill materials have been historically placed, throughout New Jersey. The NJDEP historic fill map shows large swaths of fill areas along the edges of Carteret (Figure 7-25). However, this map does not include all areas of fill. The NJDEP notes that the historic fill maps "show areas of historic fill covering more than approximately 5 acres."[119] New Jersey DEP notes that "most urban and suburban areas are underlain by a discontinuous later of excavated indigenous soil mixed with varying amounts of non-indigenous material. This material generally does not meet the definition of historic fill and is

[117] Map of Middlesex County, 1781.

[118] Map of Middlesex County, 1850.

[119] NJDEP 2018, pg. 1/4

not depicted on these maps. Also, there may be historic fills that are not detectable on aerial photography or by archival map interpretation and so are not shown on these maps, particularly along streams in urban and suburban areas."[120]

Figure 7-25. NJDEP Historic Fill areas

Industrial materials have a long history of use in construction, including use in concrete, road embankments, flowable and structural fill, road base, pavement aggregate, and road sub-base. The Environmental Protection Agency still encourages the reuse of industrial materials as a key component in Green Building and using such industrial waste materials can earn points in Green Building Certification Programs.[121]

Historical city council minutes and newspaper records from Carteret discuss various uses of fill materials throughout Carteret. A 1938 article from the Carteret Press discusses "the various stagnant ponds found throughout the town." The article notes that these ponds could be remedied by filling in these spots with dirt, and these ponds were eventually filled with wastes of all types.[122] In 1945, the Borough of Carteret requested the Army Corps of Engineers dump dredged material from Arthur Kill in the center of the town to facilitate one of their post-war development projects.[123]

A wide variety of wastes were used in Carteret as fill material. These wastes include garbage, ashes/cinders/slag, and industrial residues. Borough of Carteret council minutes and local newspaper records between 1907 and 1954 indicate a number of streets within Carteret were maintained with ash, cinder, and slag.[124] Newspaper records show that these

[120] NJDEP 2018, pg. 1/4
[121] EPA, 2008.Pg. 2/2.
[122] Gravel, 2019. Pg. 76/77.
[123] Gravel, 2019. Pg. 77/77.

[124] Gravel, 2019. Pg. 34/77.

three fill materials were being used concurrently to build, maintain, and repair street streets in Carteret.[125] In his deposition, Dr. Flowers, the plaintiffs' expert, testified that ash, cinder, and slag from the combustion of coal contains arsenic in quantities that can require an environmental cleanup.[126] In 1928, an article in the Carteret Press mentioned that a 'residue' furnished by the Warner Chemical Company was being utilized to fill holes and build up streets in low places.[127] The Warner Chemical Company made chlorinated solvents and baking soda at the time, but also stored significant amounts of lead on their site.[128]

In 1925, Noe's Creek, which ran through the center of Carteret and was described as an "open sewer" was filled in with cinders to "redeem" the most objectionable portion of the creek.[129] In 1938, the Borough purchased a new cinder spreader to facilitate spreading cinders on the streets during icy weather.[130]

7.2.2 Sources of Industrial Fill

The fill materials used throughout Carteret came from a wide variety of industrial sources. In 1914, there were at least 12 metal-related industries operating in the Carteret region, including USMR (Figure 7-26).[131] Metallic slags and wastes were likely generated by most of these facilities. At least 14 sources of slag and solid waste were identified along Arthur Kill- eight of these facilities (which includes USMR) were located along the southern portion of the Kill and six were located along the northern portion of the Kill, north of USMR (Figures 7-27 – 7-28).[132]

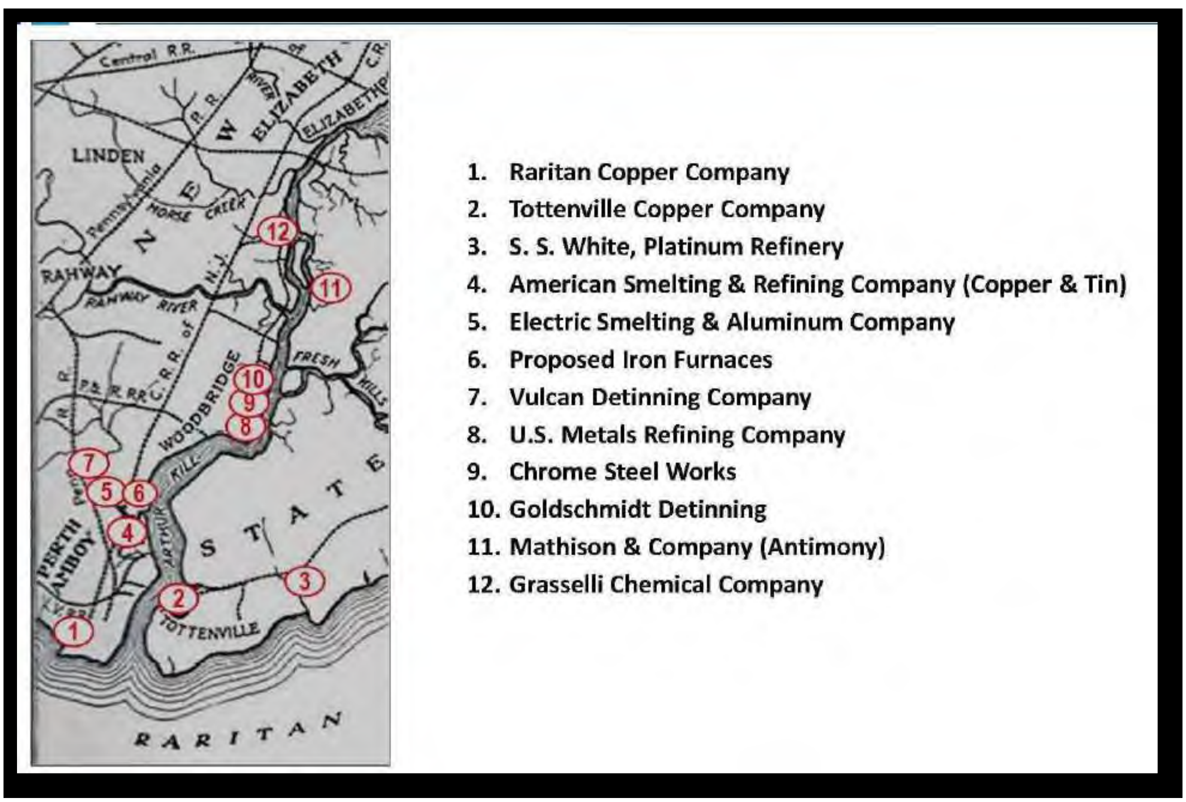


Figure 7-26. Metal-related industries in the region in 1914

125 Gravel, 2019. Pg. 34/77.
126 Deposition of Dr. George Flowers at 238-239; 242-243.
127 Carteret Press, 1928. Pg. 1/10.
128 Carteret Press, 1930. Pg. 1/16
129 Gravel, 2019. Pg. 72/77.
130 Gravel, 2019. Pg. 37/77.
131 Gravel, 2018. Pg. 61/74.
132 Gravel, 2018. Pg. 62-63/74.

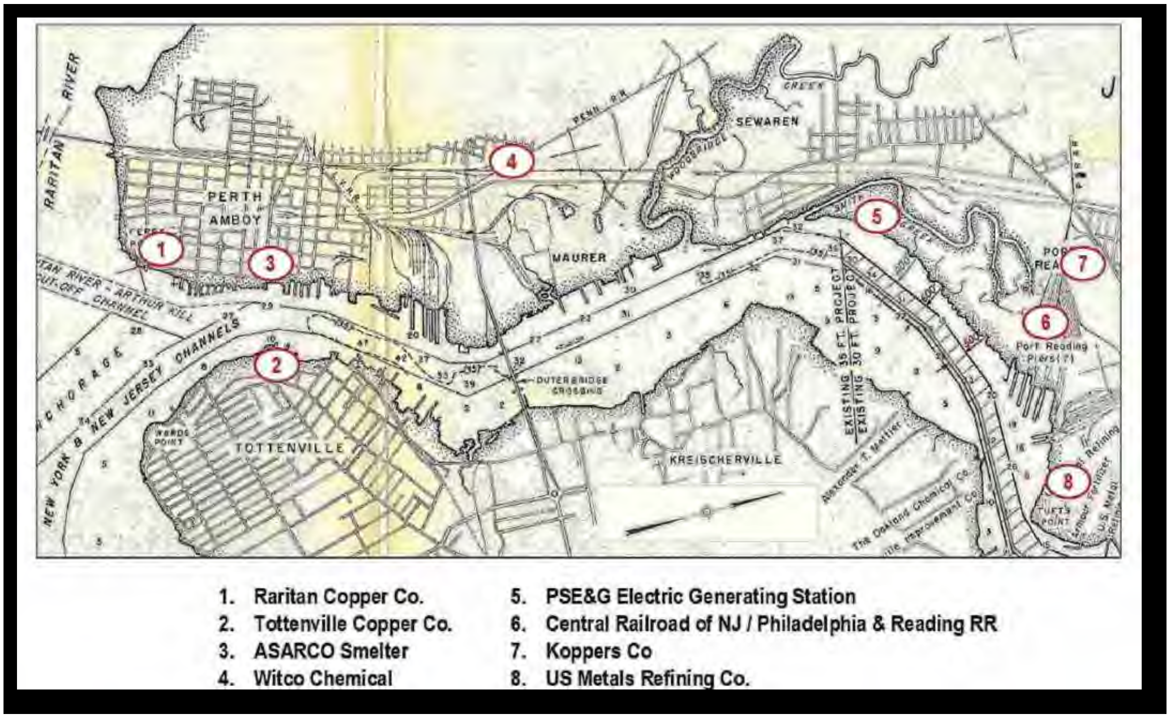


Figure 7-27. Sources of Slag and Solid Waste along South Arthur Kill

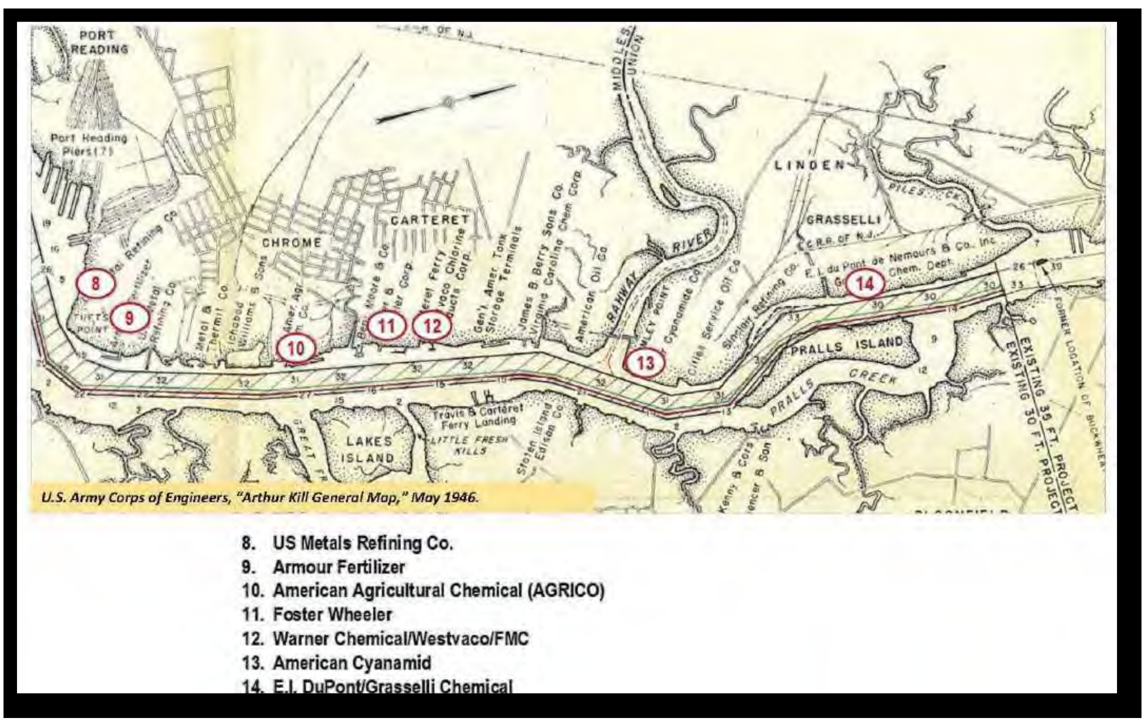


Figure 7-28. Sources of Slag and Solid Waste along North Arthur Kill

7.2.3 Visual Observations of Industrial Fill

Fill materials used throughout Carteret are often large enough to be identified by the naked eye and have been visually observed throughout the proposed class area. During my site visit to Carteret on February 6, 2018, I met with Lisa Szegedi and several remediation site supervisors with Arcadis who were working on the remediation activities in the AOC. The Arcadis personnel mentioned that they have observed a layer of fill materials on most, if not all of the properties, they had excavated.[133] During the site visit, I also visited two properties with open excavations, PPINs 3093

[133] Ms. Szegedi's observation to me is confirmed in her export report submitted in connection with this matter.

(15 Edwin Street) and 4063 (14 Passaic Street), and visually observed fill materials at both properties. A layer of slag was observed in the excavation at PPIN 4063 (Figure 7-29). This slag was a light, pumice-like slag and its appearance was not consistent with smelter-derived slags I have observed at other smelter sites.

Figure 7-29. Slag observed during excavation of PPIN 4063.

NewFields personnel have visually observed fill materials at a number of additional properties within the AOC. As an example, during the excavation of PPIN 2010 (76 Union Street), four distinct layers of fill were observed in the excavation side walls extending from ground surface down to a depth of approximately 2.5 feet (Figure 7-30). The observed layer of fill at PPIN 2010 ended at the property line, reinforcing the fact that fill activities were done on a property-specific basis. Additionally, NewFields personnel observed paint chips within the fill material at PPIN 2010.[134]

[134] Mattingly, 2019. Pg. 33/64.

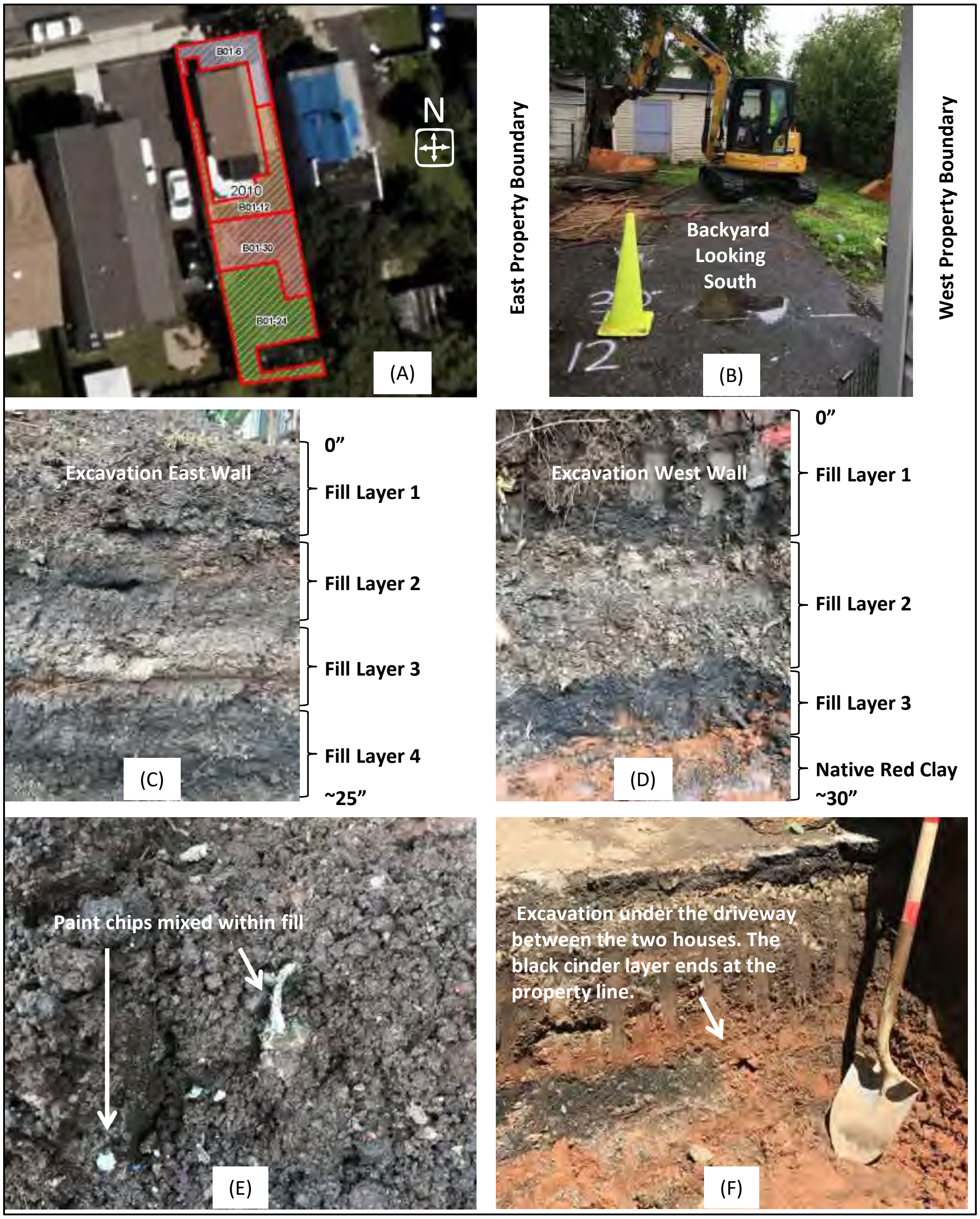


Figure 7-30. Photos from Excavation of PPIN 2010 (Figure 11 from Mattingly report)

7.2.4 Boring Log Analysis

As part of the residential soil sampling program within the AOC, USMR prepared text-based boring logs for every soil sample collected. These boring logs included the Unified Soil Classification System (USCS) code, a visual description of the sample, and the soil color based on the Munsell soil color chart. The visual description included notes on any non-soil materials observed within the sample, including fill materials. Over 71,000 boring log records were generated as part of the USMR soil sampling program.

An analysis of these logs indicates the wide-spread presence of fill materials throughout the proposed class area. Based on a review of the boring logs, several text descriptors indicative of fill or other non-native materials were identified including:

- Angular
- Fill
- Slag
- Brick
- Concrete
- Wood
- Coal
- Glass
- Cinder
- Debris
- Ash
- Vesicular
- Pumice
- Asphalt
- Ceramic
- Fabric
- Paper
- Metal
- Cotta
- Rubber
- Styrofoam
- Plastic
- Carpet
- Rug
- String

After filtering on these descriptors, indicators of fill were mentioned in 47% of the boring log records for samples that were collected and analyzed (Table 7-4).[135] Fill materials were most prevalent in samples collected from the top two feet of the soil column.

Table 7-4. Observations of fill/non-native material by depth.

Depth Interval	Count	Non-native Material Not Noted	Non-native Material Noted
0-6	6224	30%	70%
6-12	6222	37%	63%
12-18	6026	40%	60%
18-24	6038	46%	54%
24-30	4928	52%	48%
30-36	4966	61%	39%
36-42	4469	66%	34%
42-48	4436	72%	28%
48-54	1499	52%	48%
54-60	1511	67%	33%
60-66	1155	73%	27%
66-72	1176	79%	21%
72-78	852	81%	19%
78-84	850	83%	17%
84-90	821	85%	15%
90-96	837	89%	11%

Fill materials were also observed in soil samples collected by the plaintiffs. Based on information provided by the plaintiffs, fill materials were observed in at least 36 soil samples collected from six properties. These properties are primarily in the northern portion of the proposed class area, ranging from about 6,300 feet to 7,500 feet from the former USMR facility. Of the 36 samples with fill materials noted, 15 samples have concentrations of arsenic and/or lead above the NJ SRS criteria.

7.2.5 Forensic Microscopy and Excavation Inspections

Forensic microscopic analysis conducted by Steve Mattingly also points to the widespread use and presence of fill materials in Carteret. In his microscopic analysis of soil samples from the AOC and transects, Mattingly identified a wide

[135] Boring logs were generated for all samples collected, but not all samples that were collected were analyzed by the laboratory.

variety of fill and non-native materials including cinders/coal/ash, construction debris, solder balls, black glassy slag, and other materials. Additionally, Mattingly analyzed samples of slag from Parcels 7-1 and 7-2 of the former USMR site as well as other slags observed in AOC soil samples. The microscopic analysis shows that the slags observed in AOC soil samples differ from the slags from the former USMR site in both structure and chemical composition. This supports that there are multiple industrial sources of slag and fill materials in Carteret.

As a second component of his analysis, Mattingly and his staff visually inspected several open soil excavations at AOC properties undergoing remediation. Discrete layers of fill were commonly observed throughout the AOC, and up to four discrete layers of fill were observed at properties. These layers were bounded by native reddish soil below and on the sides of the fill layer, reinforcing that these fill materials were used for drainage and structural stability purposes.

7.2.6 Chemical Composition of Historic Fill

The NJDEP has mapped the large areas of historic fill present in low-lying areas throughout New Jersey, including the Carteret area. These fill materials often have elevated levels of metals and other contaminants. NJDEP has also developed contaminant concentrations associated with historic fill. Historic fill has an average arsenic concentration of 13.15 ppm with a maximum concentration of 1,098 ppm and an average lead concentration of 574 ppm with a maximum concentration of 10,700 ppm.[136]

Soil samples from the proposed class area with fill/non-native materials noted in the boring logs tend to have higher concentrations, on average, than samples without fill. Figures 7-31A and 7-31B show average arsenic, copper, and lead concentrations by depth interval (represented by the average depth of each sample). Figure 7-31A shows the average concentrations for samples where fill materials were **not** noted in the boring logs while Figure 7-31B shows the average concentrations for samples where fill materials **were** noted in the boring logs. These figures show that the samples with fill/non-native materials have higher concentrations, on average, than those that do not contain fill/non-native materials.

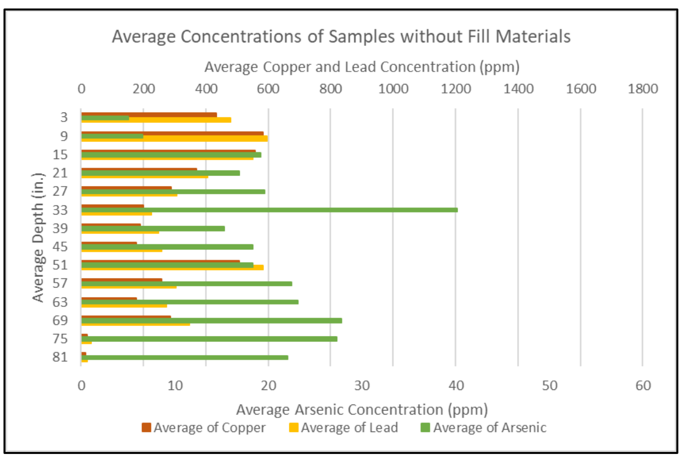


Figure 7-31A. Average Concentrations of samples by depth without fill materials

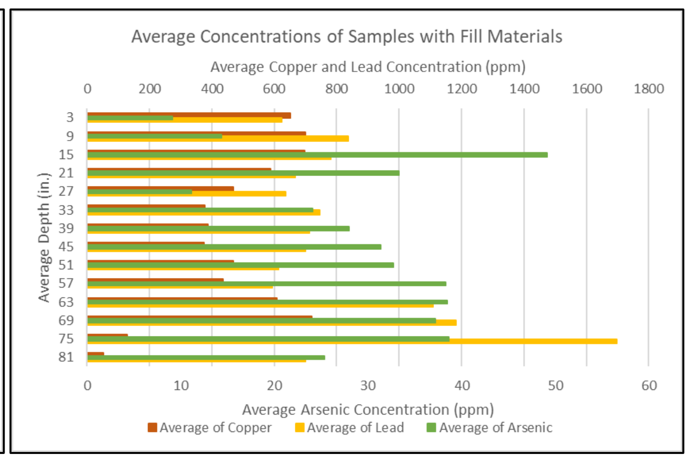


Figure 7-31B. Average Concentrations of sampled by depth with fill materials

Mr. Mattingly's microscopy analysis also confirmed the presence of elevated lead concentrations in construction debris fill materials originating from both LBP and from solder, which is composed of lead and tin.[137] In addition, thermogenic sourced fill materials (slag, cinder, and ash) are widely observed within the proposed class area and the process of combustion preferentially removes organic material and concentrations inorganic materials, thus enriching the heavy metal components.[138]

[136] NJDEP SRP, Historic Fill Material and Diffuse Anthropogenic Pollutants Technical Guidance. Pg. 5/47.
[137] Mattingly, 2019. Pg. 61/64.
[138] Mattingly, 2019. Pg. 21/64.

7.3 Opinion 3-3: Historical Commercial Activities

The presence of historical commercial operations within the class area resulted in isolated 'hot spots' of metals concentrations that impacted specific individual properties throughout the proposed class area.

7.3.1 Sanborn Review

NewFields obtained all available Sanborn Fire Insurance Maps for the Carteret area from 1891 through 1969. Sanborn maps are highly detailed and include information on building footprints, building heights, building uses, construction materials, and other information.[139] The Sanborn maps were georeferenced in the NewFields GIS database, allowing the maps to be viewed in their correct spatial location and in conjunction with current and historical aerial imagery and soil data collected from within the proposed class area.

A review of the Sanborn maps in conjunction with the soil data shows several 'hot spots' of metals concentrations that are associated with historical commercial operations identified on Sanborn maps. Two example properties where metals concentrations are impacted by these unique site-specific conditions are discussed below and in more detail in section 9.1.

<u>180 Pershing Avenue (PPIN 7337)</u>

The property at 180 Pershing Avenue has elevated levels of arsenic, copper, and lead in soils in the backyard of the property. A review of the Sanborn maps for this area revealed several historical features that are no longer present:

- The 1912 Sanborn map shows a shed/detached structure present in the backyard in the vicinity of the sampled area (highlighted in yellow on Figure 7-32)
- The 1912 Sanborn map also shows that 180 Pershing was adjacent to the print shop for the Roosevelt News, which also had a shed/detached structure present in the back of its property, immediately adjacent to the 180 Pershing property boundary (highlighted in yellow on Figure 7-32).
- The 1969 Sanborn shows the print shop is still present but has expanded significantly (highlighted in yellow on Figure 7-33).
- The 1969 Sanborn also shows an auto body shop on the same block as the print shop and the 180 Pershing property (highlighted in yellow on Figure 7-33).

As is explained in greater detail in Section 9-1, inks and used cleaning solvents from the operation of a print shop (and potentially stored in the shed at the back property line) contain metals, particularly copper. As discussed above, previously demolished structures are a source of LBP. Auto repair shows are also known sources of metal contamination. To understand the source of metals at 180 Pershing Avenue, these site-specific sources must be evaluated and assessed.

[139] Sanborn Map Company, 2017.

Figure 7-32. 1912 Sanborn Map of PPIN 7337

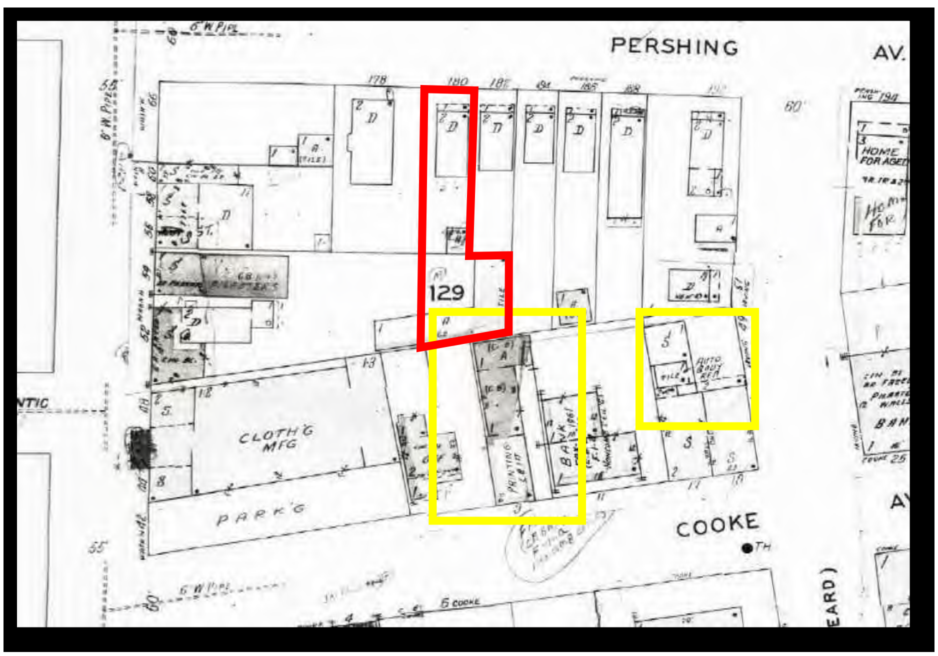


Figure 7-33. 1969 Sanborn Map of PPIN 7337

208 Pershing Avenue (PPIN 7355)

The property at 208 Pershing Avenue has elevated levels of arsenic, copper, and lead in soils in the side yard and back yard of the property. The 1931 Sanborn map for this area shows a large garage/auto shop immediately adjacent to the 208 Pershing property (highlighted in yellow on Figure 7-34). This auto shop is visible in a 1966 aerial of the property, and numerous cars are visible on the property (highlighted in yellow on Figure 7-35). The auto shop is still visible in the 1969 Sanborn (highlighted in yellow on Figure 7-36), and based on a review of aerial imagery, the property was converted to a parking lot sometime between 2006 and 2015.

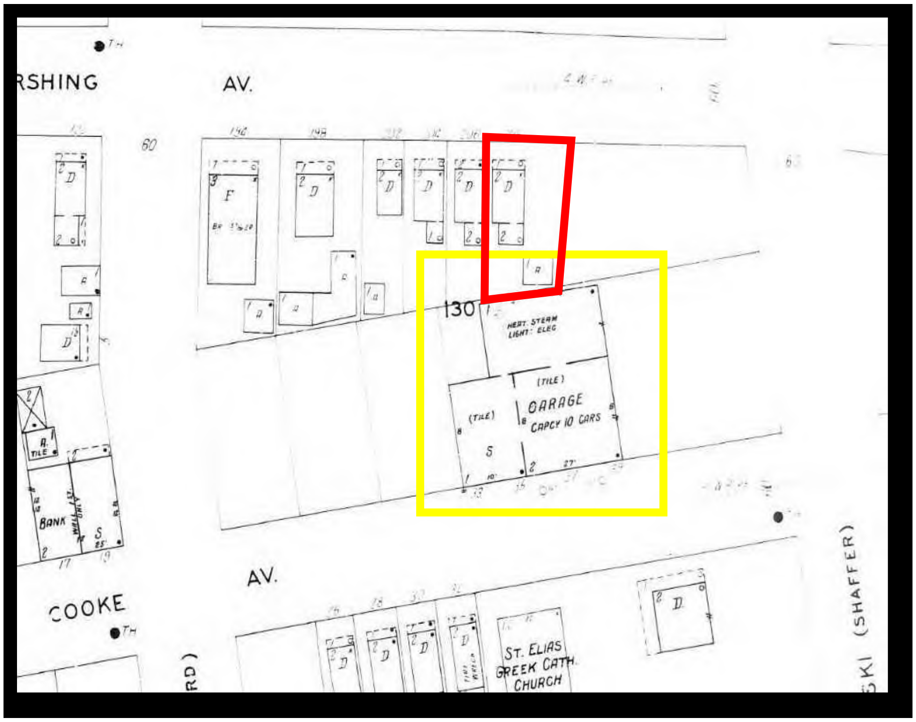


Figure 7-34. 1931 Sanborn of PPIN 7355

Figure 7-35. 1966 Aerial

Figure 7-36. 1969 Sanborn of PPIN 7355

7.3.2 Federal and State Site Registries

Both the USEPA and NJDEP maintain databases of known or potentially contaminated sites. The USEPA maintains the Facility Registry Service (FRS) database which is a centrally managed database that identifies facilities, sites, or places subject to environmental regulations or of environmental interest. The FRS serves as a single integrated source of comprehensive environmental information about facilities.[140] The USEPA FRS database contains over 500 sites located within the proposed class area (Figure 7-37).

The NJDEP also maintains a list of Known Contaminated Sites. These are properties where "contamination of soil and/or groundwater has been confirmed at levels equal to or greater than applicable standards."[141] There are 59 properties in or adjacent to the proposed class area on the Known Contaminated Sites list (Figure 7-38). These properties include an agricultural chemical company, auto body shops, gasoline and oil facilities, and a manufacturer of dyes and pigments. This large number of registered sites suggests that there are dozens of properties within the proposed class area like the two properties on Pershing Avenue discussed above that have been influenced by prior localized commercial operations.

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[140] EPA Facility Registry Services, https://iaspub.epa.gov/sor_internet/registry/facilreg/home/overview/home.do

[141] NJGIN, Known Contaminated Site List for New Jersey. https://njogis-newjersey.opendata.arcgis.com/datasets/njdep::known-contaminated-site-list-for-new-jersey-non-homeowner

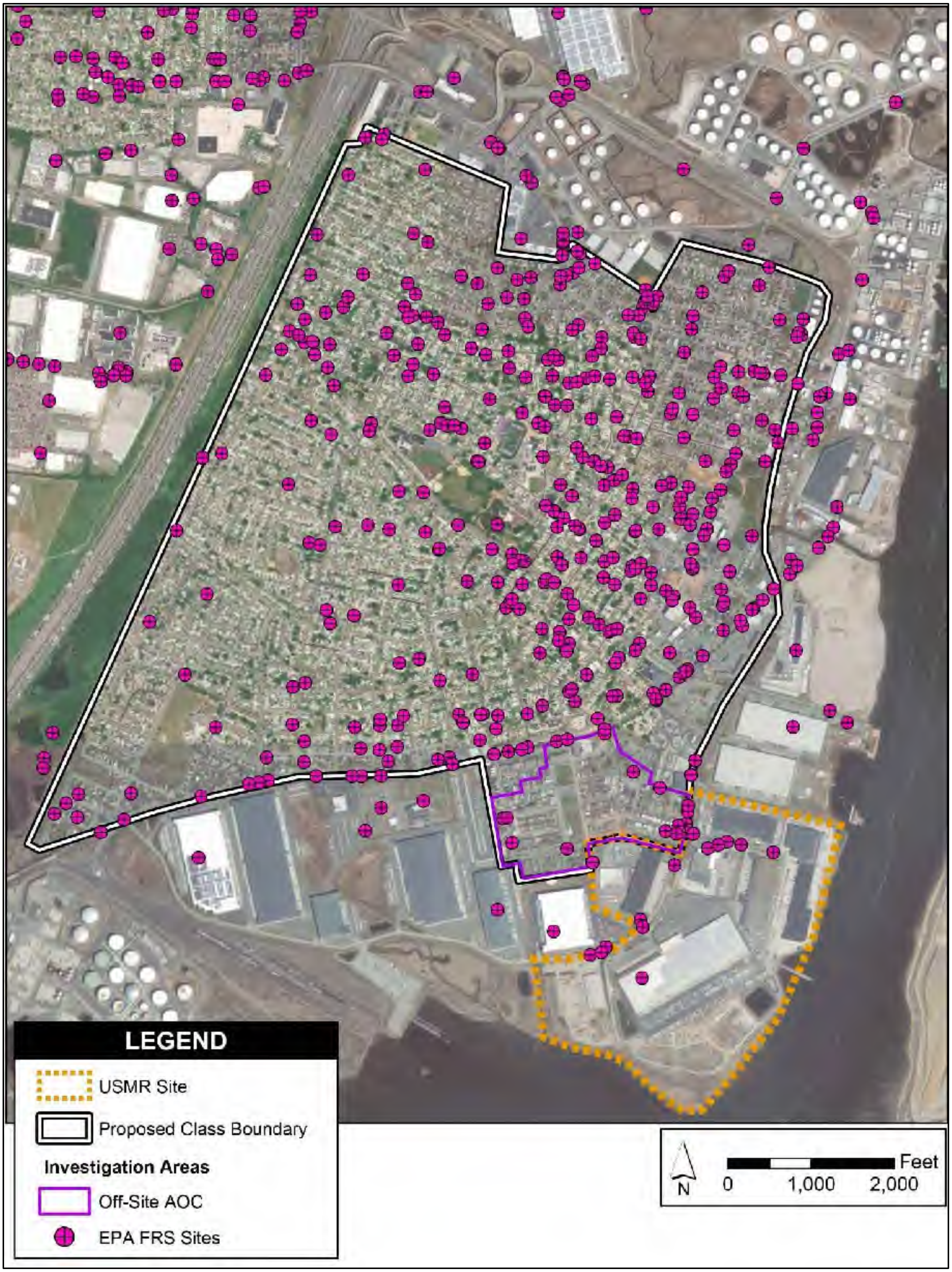

Figure 7-37. USEPA FRS Sites

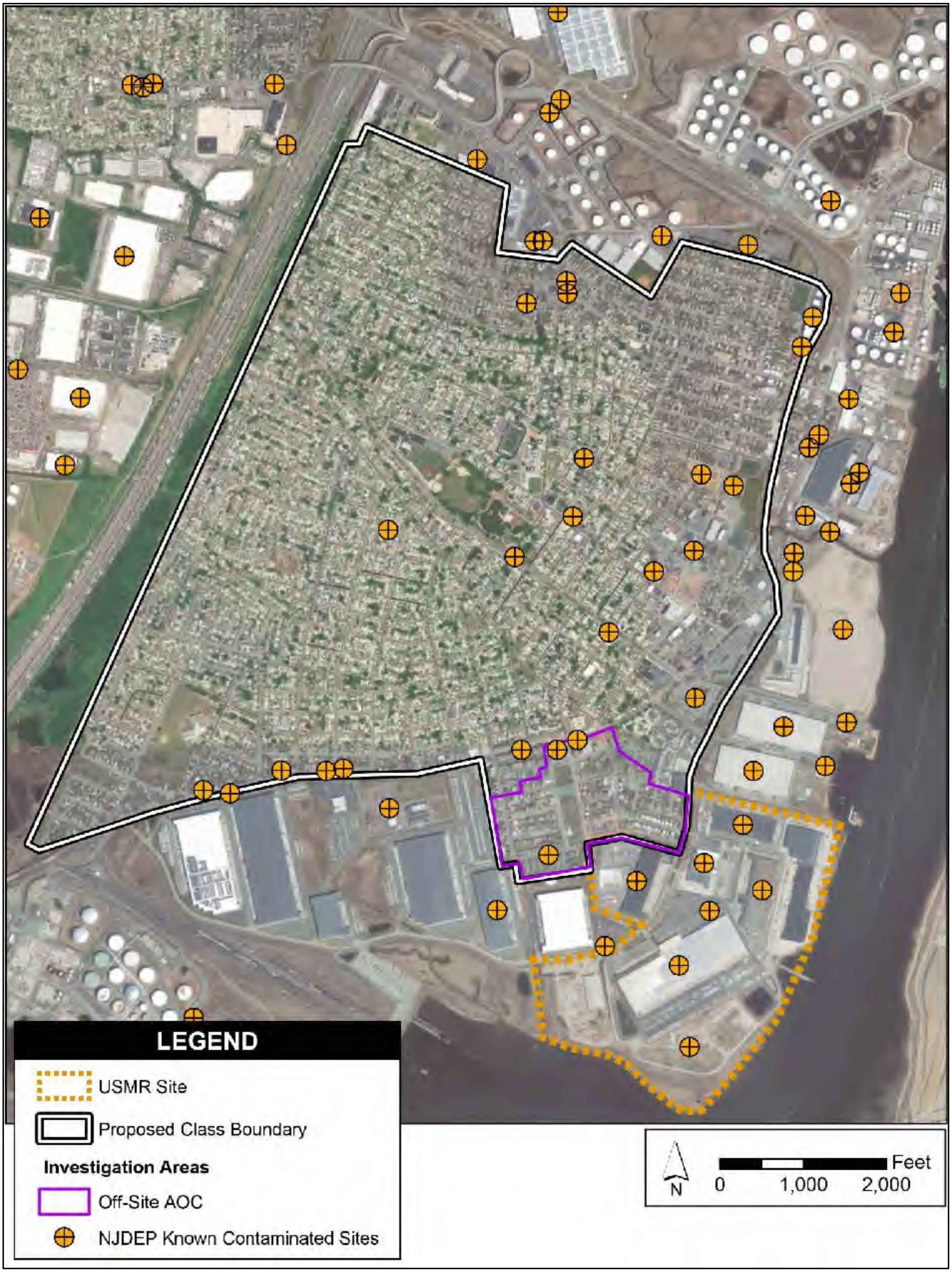

Figure 7-38. NJDEP Known Contaminated Sites